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THE QUARTERLY
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I. THE DOLMEN-MOUNDS AND AMORPHOLITHIC MONUMENTS OF BRITTANY.

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Part I.

The Dolmen Mounds of Brittany; their History and Analogues.

THE study of prehistoric archæology has now become a recognised branch of accurate if not exact science, by which valuable assistance is rendered towards the elucidation of many problems of universal interest in philosophy as well as ethnology. It increases our knowledge of the progress of human thought as exhibited by the habits, occupations, and arts of primitive man, whilst it also furnishes a clue to the intricate currents of the tide of ethnic migration; the first is supplemented by comparison with analogous modes of life, still found in existence amongst tribes of modern savages, whilst the latter throws light upon the primeval relationship of peoples, whose descendants are at present separated by broad intervening obstacles, whether seas, deserts, or other races of foreign stock.

Brittany offers to the ethnologist an unusually wide field for investigation in this direction; "*La clef de l'ethnologie de la France est en Bretagne*," says Professor Broca, and the numberless megalithic remains to be found in this province, especially in the departments of Finistère and Morbihan, offer promising mines of research. Brittany may well be called "*La Terre des grands souvenirs*." Amongst these interesting monuments, M. de Freminville is a sure guide to their localities, as indeed he is to all the Breton antiquities, which he has made his especial study.

M. de Freminville divides the megalithic (sometimes wrongly termed cyclopean) remains under three heads:—1. Religious; 2. Sepulchral; and 3. Memorial; and he attributes them all to Celtic construction.

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1. In the first group he places all the dolmens and demi-dolmens, which, following the popular ideas of his time, he supposes to have been Druidic altars, on which human sacrifices were performed, from the summit of which Arch-Druids preached, and inside of which they also had their habitation: where also an eternal pyre was kept burning, from which source the neighbouring Gauls daily obtained fire for their own domestic hearths, which were each night extinguished by the inexorable Celtic law of *couvre-feu*, the origin of which is lost in the gloom of prehistoric ages. He places also under this class the circular and other enclosures of upright stones, which he supposes to have been Druidic temples and sanctuaries.

2. The sepulchral group include the *menhirs* and alignments of *peulvens*, as also the confused assemblages of stones called in Celto-Breton "*Carneilloux*," which the Chevalier supposes to have been cemeteries, the grave-mounds or tumuli, to some of which, when composed simply of stones heaped upon one another (cairns), the distinguishing Celtic name of *galgal* is given.

3. To the memorial group are referred the isolated *menhirs* of extraordinary size, commemorative of victory or some momentous event.

Such were the ideas generally received some five-and-thirty-years ago, when De Freminville wrote; but since, a more perfect knowledge of various facts connected with these monuments has wrought a revolution of opinion, and the term Druid's altar is now obsolete, and no longer to be found in the antiquary's text-book.

After careful examination of numerous cromlechs and tumuli by excavation, the study and comparison of their varied contents has led the first archæologists of the day to conclude that *all dolmens* were originally covered with tumuli*, and that one and all of these and analogous structures are satisfactorily proved to be of a sepulchral character. The circles and alignments are, however, by some excluded from this category, but they are admitted to have had some connection with funeral rites and ceremonies.

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* I include in the word *dolmen* all megalithic chambers, whether enclosed in mounds or deprived of their primitive coverings, and in treating of Breton monuments I insist on their tumular character as a principle of universal application. I know and admit of no so-called dolmen which does not or should not come under this rule. This megalithic structure is a tomb in every stage of dilapidation. It may be found totally enveloped or partially exposed, or wholly denuded, and in every intermediate state, in which may be detected the vestiges of the original tumulus. Instances of complete denudation are comparatively rare.—Rev. W. C. Lukis.

It is to local museums that we must look for collections of the stone implements, ornaments, pottery, &c., found in the ancient sepulchres of the surrounding country; and in this respect the Bretons are not behindhand. The Museum formed by the Societé Polymathique of the Department of the Morbihan at Vannes is well worth a visit from every student in prehistoric archæology, and, although small, the collection of neolithic implements and ornaments is well assorted with special regard to the localities in which they were found. By inspection of the catalogue which enumerates and classifies these "*objets de l'age de la Pierre Polie,*" it appears that the museum contains 198 good specimens of stone celts, besides fragments, as well as flint knives, scrapers and flakes, hammer-heads, gorgets, torques, pendants, &c., all from the surrounding department. The other principal collections of relics of the stone period, from Brittany, are at St. Germain's, at Plouharnel (Madame Le Bail's), Mr. Lukis's Museum in Guernsey, and Mr. William Lukis's collection in Yorkshire. Our public collections in England are remarkable for their deficiency in Brittany examples, there being but one in the British Museum, and the Christy Collection, which is rich in celts from the Auvergne, has nevertheless none from Brittany. In the Blackmore Museum at Salisbury are a few specimens given by Mr. Barnwell, but this model museum possesses an instructive series of casts from those in the Vannes Museum.

In respect to pottery, the Morbihan collection is poor, whilst there is but a scanty show of flint-knives, flakes, and arrow-points; with regard to the arrow-points, Mr. Lukis says,—

"It is a circumstance which should be mentioned with reference to the flint arrow-points, that the members of the Polymathique Society of the Morbihan, after fifteen years' labours, have succeeded in finding two only, and this circumstance has led them to remark that these objects are very rare in the department; but I entertain a different opinion, and conclude that they have not searched carefully, for in one chambered barrow I have found *nine*, in another *three*, and in a third *one;* in each case after a previous disturbance of their contents. They are small objects and easily escape detection, more particularly when explorers neglect to use a sieve. The truth is that explorations of these buildings are generally carried on too rapidly, especially by those whose place of residence is at a distance, as well as by those who employ paid labourers, to whom, therefore, time is of great consequence."*

The French *savans* have since been more successful in finding these smaller relics. The accounts of the explorations of the various tumuli, published by the society from time to time in small pamphlets, are unusually interesting. It is indeed enough to make our island archæologists die of envy to read M. Galles's account of the mining and excavation of the huge tumulus of Mont San Michel, in September, 1862. There is an almost exciting description of the moment when, a shaft having been sunk from the summit, the small sepulchral chamber was first broken into, and the enthusiastic explorer, placing his lamp within the aperture, sees the glistening of the polished celts, jasper and turquoise beads, &c.; and how, when entering alone into the small kist, he hands out to his colleagues, Louis Galles ("*qu'Hoffman eût nommé l'homme aux dolmens*") and M. Lallemand, one by one, these valuable relics, amongst other things, eleven jade celts and six-and-twenty small ones of fibrolite.

Unfortunately the members of the society could not always be on the spot during the progress of the excavations, and consequently many valuable celts and other ornaments from this same tumulus are in possession of the neighbouring farmers and peasantry, who are not unwilling to sell them, whilst the proprietors of the small inns at Carnac have some handsome specimens, which they keep to exhibit to tourist visitors, &c., and of the value of which they have rather an exalted opinion. "Helas!" exclaims M. René Galles, "Le dirai-je; nos paysans vendent aux Anglais les celtæ de leurs pères!"

It may here be noted, for the information of visitors to this locality, that there is a notorious manufacturer of pseudo-celts in the village of Carnac.

The tumulus of Tumiac, on the Arzon promontory, was one of the earliest attacked by the Vannes Society, where the find was rich and encouraging; similarly, Manné-Lud, at Locmariaquer, Le Moustoir, and the barrow in the grounds of Baron Walbrook, at Kercado, with others, have been opened with varied success; but perhaps the best worth recording is the discovery of the dolmen under the large mound named MANNÉ-ER-H'ROËK.

MANNÉ-ER-H'ROËK is a conspicuous tumulus outside the village of Locmariaquer, close to the sea-shore, and not far from the Pte. de Kerpenhir, at the entrance to the Gulf of the Morbihan. On the French naval charts it bears the name of "*Butte de César*," but the only name by which it is known to the native peasantry is *Manné-er-h'roëk* (Montagne de la fée). According to the French account, it is a long barrow, measuring over a hundred yards in length by 60 in breadth, whilst it has a height of 33 feet. Its longer axis is what would be termed orientated by those who see orientation in all these remains, although it is within two degrees of the S.E. and N.W. points of the compass. Mr. Lukis considers this tumulus to have been originally round, and that its elongated appearance at present is owing to its sides having been removed in the course of agricultural operations. At its base on the N.E. side are two fallen *menhirs* of considerable size, whilst some smaller stone, not far from the present base in the opposite direction, may perhaps be taken to indicate the remains of a *peristalith* which once surrounded the grave-mound.

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* On a Remarkable Chambered Long Barrow, at Kerlescant Carnac, Brittany, by Rev. W. C. LUKIS, p. 6.

In September, 1863, M. Lefebvre, the Préfet of the Morbihan, and M. R. Galles, caused this barrow to be explored; a party of soldiers under their direction soon sank a large crater about the middle of the mound, and it was found that it was a galgal built up in the usual way, of rough stones piled one on another, and not dissimilar to the analogous mounds at Tumiac and Mount St. Michel. Not far from the summit they found in the course of clearance some Roman coins and *débris* of Roman vases; deeper they found beads of enamel, jasper, and agate; until in the very centre they arrived at a sepulchral chamber 12 feet long, 8 feet broad, and 5 feet high. It was not a megalithic dolmen, but consisted of three roofing-slabs supported by dry walling, and, according to Mr. Lukis,* who groups the dolmens according to the construction of their roofs, may be termed a *ceiled* in contradistinction to the *vaulted* sepulchre. Outside the entrance to this rude cell were found the three fragments of a stone tablet with curious incised archaic sculpturings upon them. These appear to belong to an altogether different type of pattern to the elaborate ornamentation of Gavr' Inis, and more resemble the ruder engravings found on the slabs of Manné-Lud and on the large cap-stone of the Table des Marchands; the peculiar pattern, which is generally understood as representing the hafted celt, occurs in all the latter dolmens as well as in the chamber of the tumulus at Kercado. There may be some analogy between this memorial tablet being buried at the entrance to the chamber under the enormous galgal, and the ancient custom of the Scandinavians, as shown by the finding of rune-stones inside the cairn during the oldest period of the iron age; whilst the rich decorations and hieroglyphics beautifully inscribed on the sarcophagi of the Egyptian and Oriental tombs point in the same direction. The fact of some of these rude characters being surrounded with a species of cartouche or label in the case of the Manné-er-H'roëk inscription is worth noticing from the fact that it is also found according to Professor Stephens, of Copenhagen, enclosing Runic characters, but only of the most ancient description, whilst its frequent appearance on Egyptian and Phœnician monuments is well known. On the pavement of flat stones in the interior of the chamber were found exposed two celts and a ring, both of jadeite, with three jasper pendants. The ring is partly oval, flat, and polished, and is the only one of its kind in the Museum at Vannes. Somewhat similar rings have been found in Guernsey, where they are in Mr. Lukis's Museum. One of these shows signs of wear, and it is conjectured that they were probably worn as a gorget;* they are too small for the wrist. But perhaps the most remarkable feature in the exploration of this chamber was yet to follow, and that was the discovery under the pavement before-mentioned of the extraordinary number of 101 celts, 91 of which were of *fibrolite*, small, sharp, and perfect, whilst the larger ones of jade, diorite, &c., were more or less fractured; some of these last are noticeable as being pierced for the purposes of suspension.

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* "On the Various Forms of Monuments commonly called Dolmens in Brittany, pointing out a Progress in their Architectural Construction, with an Attempt to Reduce them to Chronological Order." By the Rev. W. C. Lukis, M.A., F.S.A.—"Transactions of International Congress of Prehistoric Archæology." Third Session.

Such an unprecedented find of celts has never before or since been equalled, at least in Europe; whilst the enormous proportion composed of that rare material called *fibrolite*, which is not known in Europe as a native substance, is also astonishing.

The significant facts, that all the small fibrolite celts are in good preservation and appear to have never been used, whilst the rougher and larger specimens show signs of wear, and were also apparently purposely* so fractured when deposited, are well worthy of our closest attention.

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* Flint Chips, p. 104. By E. T. STEVENS, Hon. Curator of the Blackmore Museum.

Now it is found that in all interior or sepulchral finds the celts made of fibrolite are at least 75 per cent of the whole number found, whilst the surface and miscellaneous finds produce but few of this material, being generally of diorite and porphyry; thus, wherever found, the fibrolite celt is indicative of sepulchral associations, and was evidently not made for daily use. A superstitious reverence probably attached to the rare stone, as in China at the present day the possession of a certain amount of jade† entitles the owner to a certain rank, and as the jade celt also confers certain rights of chieftainship in New Zealand. This celt may also have been used as an amulet or talisman, like the siger stone (victory-token) and life-stone (against wounds and death) used by the Norse and Swensk adventurers of Scandinavia, which were worn on their weapons or armour, or on the person in a small bag, and accompanied them to the tomb.‡

Although there is a slight difference in the exterior contour of the great Dolmen-mounds of Tumiac, St. Michel, and Manné-er-H'roëk, the first being most conical, and the second much the longest of the three, still they may be placed in the same class as to their structure, being all composed of alternate layers of sand and stones, the implements found inside of them being also similar. Therefore we may with tolerable certainty assign them to a contemporary period and the same race of builders.

At the same time Mr. Barnwell has rightly pointed out the different methods of interment practised in each mound; thus, in the chamber of Tumiac, the body had been placed in its natural state, whilst in that of St. Michel complete incineration had first taken place. In Manné-er-H'roëk, on the other hand, no human bones or least trace of them could be found by the explorers. Could this last have been a cœnotaph?

Whilst on the subject of *cremation* and *inhumation*, and as an additional proof that both were practised at the same time* we may notice the curious elongated tumulus of Manné-Lud in the same neighbourhood, being only a mile distant from Manné-er-H'roëk. Here in one chamber were found the remains of two human bodies, side by side, one of which had suffered incineration and the other simple interment. At the western extremity of this mound a magnificent megalithic dolmen has long ago been exposed, whilst at the eastern extremity the explorers found a curious arrangement of stones with an assemblage of burnt animal bones, as if an holocaust had been burnt in sacrifice. A parallel instance of finding the bones of animals occurs in an oblong barrow at Dalby Tyrstrup-hundred, South Jutland, where the skeleton of an ox was discovered in 1840; a golden head-ring was also found in the same mound.

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* The spoon, mat, pillow, and spears of a dead Kaffir are laid beside their owner in the grave; the shafts of the latter are always broken and the iron heads bent, perhaps from some vague idea that the spirit of the deceased will come out of the earth and do mischief with them.—Rev. J. G. Wood, Africa.

† "To Heaven alone is offered a piece of blue jade, cylindrical in shape and a foot long, formerly used as a symbol of sovereignty."—"Sacrifice by the Emperor of China." *Vide* WILLIAMSON's Journeys in North China; ch. xvi., "Peking," by the Rev. JOSEPH EDKINS, B.A.

‡ Professor STEPHENS.

According to Mr. Lukis, the practice of burning the dead was nearly unknown to the builders of the megalithic dolmens. The eastern portion of the tumulus of Manné-Lud is probably of later date than the dolmen at the west.

The next example of a dolmen under a tumulus, viz., that of Kercado, is taken as presenting a complete contrast to those of Manné-er-H'roëk, St. Michel, &c.; as those huge tumuli enclose but rude, small, and imperfect sepulchres, whilst this modest hillock, one-tenth of their bulk, contains within an highly finished megalithic dolmen, consisting of a square chamber and gallery of upright blocks supporting large cap-stones. On one cap-stone and on two of the side blocks are signs of rude ornamentation. It is suggested with great probability by M. Galles that this tumulus must have been despoiled of its contents previous to the visit of its late examiners in 1863, as but few objects of human workmanship were found within, whilst bones comparatively well preserved, with Roman pottery, were found within, indicating, according to the Marquis de Valory, that the Romans had used this aboriginal tomb as a place of burial during their occupation of Armorica. A minute jadeite celt was found, a larger one of diorite with *callaïs*† beads and some pendants of talc, agalmatolite, and mica-schist, interesting on account of their similarity with articles found in the lake dwellings of Switzerland.

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* A modern instance of several kinds of sepulture being practised by the same people at the same time is to be found in Thibet. The Llamas of Thibet, according to Huc, have four methods of disposing of their dead, viz.:—1. Combustion; 2. Immersion in rivers and lakes; 3. Exposure on the summits of mountains; and, 4, the most esteemed—Cutting up the bodies in pieces and giving them to the dogs. As to this last method, the poor people have the dogs of the suburbs for their mausoleum, but for persons of distinction a little more ceremony is used. There are convents where sacred dogs are kept on purpose to devour the corpses of rich Thibetans.

† Le nom de callaïs a été imposé par M. Damour au minéral qui forme nos grains de collier. Le couleur de cette matière est le vert-pomme, se rapprochant

Another unusual type of dolmen is exhibited by that exhumed at Kergonfals, in the Commune of Bignan, near Locmine. In the first place, it is in the interior of the department, at a considerable distance from the sea coast, and therefore it is an exception to the generally received supposition that the dolmens are universally found by the shore, as the majority certainly are; but this, with other examples, seems to prove that it is only the richer cultivation of the interior which has caused the demolition of the stone structures, whilst the exposure of the site and sterility of the soil have been the means of saving similar remains on the coast from the plough of the farmer. Again, the tumulus of Kergonfals is not built, as usual, on the summit, but on the side of a slight eminence.

In company with two other dolmens, *viz.*, Le Rocher in Plougemelen and Les Pierres Plates at Locmariaquer, the *allée couverte* forms an angle. The plans of all three dolmens exhibit a decided curve, although in different directions.

Another unusual feature at Kergonfals, also, is that the eastern extremity of the gallery is at a higher level than the chamber and adjacent passage, into which there is an abrupt descent; two portions, also, of dry walling divided the gallery when first explored. The interior find was not large, comprising three blunt quartzose cells of rude type and imperfect polish, two flint knives, and an empty pottery vase; but the explorers were fortunate in obtaining some human bones, from a careful observation of whose position an expert anatomist (Dr. Mauricet) was enabled authoritatively to state that they were the bones of a strong and athletic man, whose body had been placed in a sitting or crouching

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du vert de l'émeraude. Quelques echantillons sont comme marbrés de parties blanches et de parties bleuatres; d'autres sont maculés de veines et de taches brunes ou noires, par suite d'un mélange accidentel de matières argileuses. Le mineral est translucide, à peu près autant que la chrysoprase. Sa cassure est compacte comme celle de la cire. Il raie le calcaire, mais il est facilement rayé par une pointe d'acier. Sa poussière est blanche, infusible au chalumeau. Cette substance est un phosphate d'alumine hydraté comme la turquoise orientale, mais elle en diffère sensiblement, aussi bien par les proportions de ses principes constituants que par ses caractères extérieurs. M. Damour, d'après les différences appréciables que existent entre ces deux matières, les sépare dans la classification des espèces. Il emprunte à Pline le nom de callaïs, qu'il applique à notre minéral, et réserve celui de turquoise à la pierre précieuse de couleur bleu de ciel, si comme en joaillerie.—Voir la description de la callaïs par M. DAMOUR; Comptes Rendus de l'Academie des Sciences, Tome lix., Séance du 5 Décembre, 1864.)

posture, with the head down on the knees; a decision which undoubtedly proves the tumulus of Kergonfals to have been a place of sepulture by inhumation.

This burial in a sitting or crouching posture seems to have been usual, at various periods, among the dolmen-builders, as similar examples have been found in Scandinavia, as at Goldhaon, in the Channel Islands, as at Du-Thus, opened by Mr. Lukis, where two skeletons were found, under the cap-stone of one of the small northern chambers, in a similar position. At Charlton Abbots, in Gloucestershire, were found as many as twelve, and at West Kennet, Wilts, six bodies, all in a sitting position; so, also, at Uley and Avening the same position is noticeable. Nor are there wanting modern instances of burial in the sitting posture, which is practised amongst the Japanese, Australians, and Esquimaux. Among the Kaffirs, also, the body is never laid prostrate, but the body is placed in the grave in a sitting posture, the knees being brought to the chin and the head bent over them.*

Some very slight traces of artificial working of the interior stones seem to have been considered as doubtful by the explorers. We cannot but regret, in reading Mr. Galle's account of this examination, that his party thought it necessary to remove several of the cap-stones in the course of their work, which, from our experience, can never be really necessary. He says:—"Nous nous décidâmes à regret à enlever les deux premières tables, apres avoir pris un croquis exact de l'état des lieux."

The better-known hollow tumulus of Le Rocher, which has been noticed above, was cleared out by the late M. Bain, the owner of the neighbouring property, as long back as 1844, and the few objects found therein are still preserved by his widow: these principally consist of a few fragments of pottery, one of which was the base of a vase, containing beads of blue jasper and dark jade, with a blade and arrow-head, both of flint.

The grotto itself, beneath the superimposed galgal, or cairn, consists of thirteen broad and flat cap-stones, supported by upright slabs, the interstices between which are built up with dry walling. The angle which the eastern gallery makes with the western portion is as nearly as possible in the centre of the structure; the angle is 125°, whilst that at Kergonfals is more acute, being 108° only; as usual, the *allée* itself and the stones composing it are larger in width and height at the western than at the eastern extremity. Here we may observe that this is one of the few monuments of its kind which it is a real pleasure to visit, as it is kept free from rubbish and filth, which generally render such grottoes so disgusting to penetrate, and when illuminated presents a striking appearance. The last time we visited this sepulchre we found it arranged with seats at the western chamber, and decorated with garlands in honour of some little *fête*, when it presented the appearance rather of some nymph's retreat than a dismal charnel-house. On a bright day, after entering this vault without lights, after allowing one's eyes to get accustomed to the gloom, the daylight through the entrance is quite sufficient to render the stones in the chamber itself visible, and under these circumstances the angle of the gallery, as seen from the interior, is impressive. There is some sculpturing on one or two of the side slabs in this dolmen, which is of the same type of pattern as those found at Les Pierres Plates.

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* Some Arab tribes, in the Hadhramaut, according to Von Wrede, yet practise the ancient pre-Mohammedan (Himyaritic?) fashion of interment, with the knees drawn up to the head.

This elaborate ornamentation, which is a marked characteristic of some of the dolmens, may help archæologists in determining the relative antiquity of the monuments in which it is found. The most ancient markings are most probably the so-called cup-markings, which have successfully baffled hitherto all enquirers as to their origin and meaning, and seem to be found in the New World as well as the Old. In the Ohio mounds, and at Orizaba, in Scandinavia, the Channel Islands, England, Scotland, Wales, Brittany, and Switzerland, they are to be seen; their interpretation remains a mystery. These cup-cuttings, in fact, hardly come under the head of Archaic sculpture.

Irregular lines and a species of net-work seem to be the earliest of any actual design or pattern, as at Kercado and Kerozille; next a pattern of pot-hooks, or boomerangs, as at the Dol-au-Marchand; all these last are rude and nearly effaced. Whilst speaking of the Dol-au-Marchand, the recent disfiguration of the western upright, which exhibits these most interesting Archaic sculpture, deserves severe reprobation. Some wilful hand has carved, with an iron tool, in the centre of the slab, the word GAZELLE, in large letters: the mere mention of this fact, and the thought that it is attributable to British visitors, is sufficient. The progress of sculpture, as developed at Pierres Plates and Gavr' Inis, is instructive. In the first the patterns are more regular, but in the last they are more elaborate, and seem even as intended to convey some information by means of their hieroglyphics.

One thing seems almost certain, and that is—that this elaborate decoration of the interior of long galleries,* leading to sculptured chambers, shows to us that these sepulchral chambers were intended to be visited subsequent to the interments; and this is the more likely, inasmuch as these galleries are so orientated (at least 66 per cent are so in Brittany) that, at some season of the year, the sun, on rising, would brightly illuminate the interior of the tomb. Ellis mentions an analogous custom amongst the Hovas, in Madagascar, at the present day. He says:—"The Hova chiefs manifest considerable solicitude about their graves; and I was told that one of the chief officers, who died lately at the capital, requested of his sons, shortly before his death, that after his interment they would occasionally remove the large stone slab that would form the door of his sepulchre, and let the sun shine in upon him." †

Mr. Lukis's classification of ceiled and vaulted sepulchres in Brittany has already been mentioned; he supposes that their various forms indicate not merely a prolonged residence of their builders in the country, but also a progress in their constructive science: thus several of their forms may have been suggested by others which have preceded them, and sometimes the side-chambers appear to be additions subsequently made to an older sepulchre, composed simply of a chamber and entrance-passage. There are many remarkable examples in Brittany of alterations, enlargements, and additions to the first building, whilst others indicate their side-chambers to have been originally planned, and to form important features of the structure; the numerous diagrams, plans, and elevations of typical examples which illustrate Mr. Lukis's paper fully bear out his theory.

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* Compare Dr. Palmer's account of the stone houses in Easter Island:—"At the south-west end of this island, at the sea edge of the Terano Kau Crater, are a number, say eighty or more, of houses of great age, now unused, mostly in good preservation, which are built in irregular lines, as the ground permits, their doors facing the sea. Each house is oblong-oval, built of layers of irregular flat pieces of stone, the walls about 5½ feet high. The doors are in the side, as in the present grass huts, and of about the same size. The walls are very thick, 5 feet at least, which makes the entrance quite a passage. On entering, the walls are found to be lined with upright slabs, say 4 feet high, but not so broad. Above these, small thin slabs are arranged like tiles, overlapping and so gradually arching till the roof opening is able to be bridged over by long thin slabs of some 5½ or 5 feet, which are not more than 6 inches in thickness and 2 feet in width. The inner dimensions of the 'hall' are about 16 paces long by 5 paces wide and the roof is fully 6½ feet high inside under the centre slabs. The passage leading to it is paved with slabs, under which is a kind of crypt or blind drain which extends to the distance of about 6 feet outside, where also it is covered with flat slabs, and is of the same dimensions as the passage. It is carefully built of stone squared and dressed; it ends abruptly and squarely. In these drains, I was informed the dead men heated were kept till required for the feasts. Outside the hall, and at right angles to it, are smaller chambers, which do not communicate with it, and each of which has a separate door from the outside. We were told that these were generally the women's apartments. The upright slabs which lined the hall, and those of the roof, were painted in red, black, and white, with all manner of devices and figures, some like the geometric figures of the Mexicans, some birds, rapas, faces, symbolic figures of Phallic nature, &c. There was no appearance of pavement in the halls, and in many of them enormous quantities of a univalve—a maritime *Neritina*—which had been used for food."—*Vide* "A Visit to Easter Island in 1868," by J. LINTON PALMER, F.R.C.S., Surgeon of H.M.S. "Topaze;" Journal of the Royal Geographical Society, vol. xl., 1870.

† ELLIS, Three Visits to Madagascar, p. 312.

The dolmen-mounds of Brittany may be classified according to the characteristics of their internal structure, as follows:—

(I.) The round barrow containing an ordinary kist-vaen, either rectangular or polygonal, covered in with one or more cap-stones. In Brittany this class does not appear to belong to the earliest period; for instance, the round tumulus in the Forest of Carnoet, in Finistère, which was explored in 1843, contained gold, silver, and silver-plated bronze ornaments, as well as flint arrow-points, whilst bronze weapons were found in another simple kist-vaen at Kerlivit, near Douarnenez.

(II.) The round barrow containing the ordinary megalithic dolmen, consisting of a chamber, with a narrow covered way or passage leading to it: this class is common everywhere throughout the province, and Mr. Lukis takes this typical form as a basis from which all the other striking varieties of ground plans observable in Brittany are deducible.

(III.) The same as the above, but containing two or more chambers, in some cases additional and in others original, as at Keriaval and Kludyer.

(IV.) In this class there are also several chambers, with a common gallery of communication; but, although the gallery is megalithic, the chambers are built up, and of the bee-hive vaulted type. A good example of this unusual type is to be found, partially exposed, at the Pte. du Rosmeur, near St. Guenolé.

(V.) Long barrow, containing long and narrow chambers; megalithic, as at Garren Dol and Parc-ar-Dolmen (Finistère).

(VI.) Same type as the above, but with tolmen, or holed entrances. A good specimen of this class has been recently destroyed near Kerlescant; fortunately before its entire destruction it was described by Mr. W. Lukis. There is a similar monument, as yet unexplored, at Kerléarec, north of the Chateau du Lac.

(VII.) Round barrow, containing a megalithic dolmen, consisting of a chamber with the gallery at a sharp angle to it. *Vide* description already given of Kergonfals.

(VIII.) Same type; gallery forming an angle with sculptured stones, as at Le Rocher and Les Pierres Plates.

(IX.) Round barrow, containing two or more megalithic dolmens, either parallel, as Plouharnel and Kerlan, or at right angles to one another, as Les Grottes des Kerozille.

(X.) Long barrow, containing a megalithic dolmen at one extremity, and other smaller kists, megalithic and built up, apparently of a secondary or additional period, *e.g.*, Manné Lud and Le Moustoir.

(XI.) Round barrow, containing long and straight avenue, square chamber, and blocks of noble proportions, highly decorated; notably Gavr' Inis.

(XII.) Immense tumuli, containing comparatively insignificant kists, partially megalithic, partially dry-walled; for instance Mt. St. Michel (Carnac), Manné-er-H'roëk (Locmariaquer), and Tumiac (Arzon).

The last five divisions are all more or less sculptured, whilst cup-markings alone are found on some of the others.

There are also found long barrows without any internal structure: these are not unfrequently accompanied by a menhir, as at Kerlescant; and in the same barrow were found two rows of small-sized blocks of stone, a species of revetment, perhaps marking the limit of the original barrow. Mr. Lukis attributes these barrows to a late period, but this will be alluded to in connection with the neighbouring alignments.

Before approaching the subject of the dolmen-builders, it may be as well to give a short description of analogous structures in the Peninsula South of France, as well as to make some mention of those which are found in such numbers in the North of Africa. The cromlechs in the British and Channel Islands are too well known to need any allusion being made to them.

In the Peninsula the cromlechs, when denuded, are known under the name of *Antas* (a term about which there has been much disputing, but which, after all, seems to signify ancient altars used as landmarks); those partially enveloped in the tumulus, or on the summit of a mound, are termed *Mamunhas* (corruption of Mamua or Mamôa—tumulus); and when covered in, as the *allées* and *grottes* of Brittany, they are termed *Furnas*.

In the year 1734 over three hundred of these remains are mentioned as existing in Portugal, but in 1868 * M. da Costa could only enumerate forty-two, of which twenty-eight are in the Province of Aleutejo, twelve in Beira, two in Traz-os-Montes, two in Minho, whilst none remain either in Estremadura or D'Algarve.

The largest aggregation of these antas appears to be at Contado d'Alcogulo, the property of M. Le Cocq, where there are five remaining together. The only stone implements described by M. da Costa were found here, and consist of half-a-dozen rude greenstone celts and a quartzite muller. With the exception of four, all the above are denuded and ruined antas; the exceptions are two furnas near Vizella in Minho, the Mamunha de Mamaltar in Beira, and the Mamunha de Carrazedo in Traz-os-Montes. This last is chiefly remarkable from the curious hollowed circular mark, presumedly artificial, on one of its supports.

There is also one curious monument mentioned, as composed of two rows of stones, near a menhir between Cepaes and Fafe, in Minho. As this is the sole description of the monument, and no dimensions mentioned, it is difficult to judge of its composition. It may be analogous to two rows of small vertical stones in the long barrow at Kerlescant, already mentioned, or there may formerly have existed an avenue of stones. Unfortunately it appears that the monument has been destroyed, and the stones made use of in the construction of the neighbouring convent of Pombeiro.

The largest and most perfect furna in the Spanish Peninsula is, however, that of Antéquera, near Malaga. This monument seems to be composed of five fine cap-stones, supported by uprights, ten on either side, of large dimensions.

The Algerian megalithic remains are much more numerous, and form vast assemblages of grave-vaults, but the structures themselves are on a much smaller scale than those of France, England, and Scandinavia.

Messrs. Férand, Bertrand, Veltnez, Bourjot, Letourneux, and Bourguignat, have all written on the subject of the African dolmens, but the name of one writer best known to English readers, not as an archæologist indeed, but as a general, is that of General Faidherbe, who was in command of the northern army of France during the late war; not very long since he gave a description of the necropoles of Constantine.

There are four principal groups of cromlechs, not to

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* Descripçao de Alguns Dolmins ou Antas de Portugal, par F. A. PEREIRA DA COSTA. Lisboa, 1868.

mention smaller ones, in the Province of Constantine, *viz.*, Roknia, Mazela, Bou-Merzoug, and Djebel-Mehmel. These consist of some thousands of megalithic tombs, arranged in straight lines, sometimes forming enclosures. All of these tombs have evidently been covered originally with tumuli, now destroyed by atmospherical agency, and in nearly every case the ancient *enceinte* of the tumulus can be traced.

General Faidherbe, who explored five apparently intact tombs at Mazela, was not successful in finding either pottery or implements. At this place the blocks composing the cromlechs are of a more regular description than the ruder ones of Roknia. At this latter place, however, M. Bourguignat * was more fortunate in his exploration of twenty-eight of these monuments, selected at various points of the necropolis. The larger tombs here contained one or two bodies, whilst the smallest alone contained the remains of three persons. Ornaments of bronze and one of silver-gilt were found in five of the sepulchres and vases of rude pottery, placed generally near the head of the skeleton. M. Bourguignat assigns these tombs to a period at least 1000 years before the Christian era, and he suggests an ingenious and novel method of calculating the ages of these structures by the layers of innumerable snail-shells found within them. At Roknia the monuments are kist-vaens, formed of four upright supports, supporting a cap-stone. At Mazela the single cap-stone, in many cases, is supported by dry-walling, whilst around them circles of stones, generally laid flat, are oftener found than at Roknia.

At Roknia the tombs are situate within a crater, where hot springs, now extinct, once existed. There is evidence that the tombs were built whilst these springs were yet in action. The neglect of the Romans and Carthaginians to utilise these hot springs, whilst they formed bath establishments at neighbouring thermal sources, is pointed out as a proof that these springs were also extinct in the time of the Roman occupation, and that, therefore, the construction of these tombs was also prior to that period.

At Bou-Merzoug the late Mr. Christy found flint flakes and arrow-heads close to the dolmens, and in the Museums of Algiers and Constantine are various stone celts and flint knives, found in connection with megalithic tombs, amongst which may be cited a diorite celt found by Mr. Dutruge close to an enormous monolith, at Kreuchela, near Constantine. Mr. Papier remarks, with regard to the flint flakes, that they are not native, as no flint is to be found in those localities, and that they must, therefore, have been imported. These implements sufficiently connect the African dolmens with the stone period of that country.

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* Histoire des Monuments Megalithiques de Roknia près d'Hammam-Neskoutin, par J. R. Bourguignat. Paris, 1868.

Mr. Palmer, of St. John's College, Cambridge, has recently given a most interesting account of some ancient remains which he discovered in the large tract of desert country known as the Negeb, or South Country, and the Desert of Et Tíh.

These remains have been attributed to the Israelites during the exodus, or to their enemies, the Amalekites, and aboriginal tribes. They are evidently the remains of large encampments; the hill-sides, for instance, at Erweis el Ebeirig, are covered for more than a mile in every direction with curiously arranged stones; the larger enclosures occupied by the more important personages, the hearths or fire-places, &c., are still distinctly to be traced, whilst there are traces of undoubted tombs outside. The Arabs call them *mahattat* (*i. e.* camping grounds), In connection with them are found *nawámís,* or circular stone huts and circles, associated with cairns and kists. The description of these huts reminds us of the assemblages of tin-washers' bee-hive stone huts and circles on Dartmoor, described by Mr. Spence Bate, and appears to belong to the same type of rude dwellings—such as Picts' houses, *brochs*, *borgs*, or *broughs*—which are found in Shetland, Orkney, Sutherlandshire, and Caithness, and described by Sir H. Dryden and Mr. Anderson. The dimensions of these *nawámís* average 7 feet high by 8 feet in diameter, with an oval top. In the centre of each is a cist, and besides that a smaller hole, both roughly lined with stones, covered with slabs of stone over which earth has accumulated. Human bones have been found in these cists, but never perfect skeletons. In the smaller cist the earth shows signs of having undergone the action of fire, and small pieces of charred wood and bone have been found. Flint arrow-heads have also been discovered in them. Mr. Palmer opened some cairns (the size of the largest of which was 20 feet in diameter, and height about 4 feet) and circles, but found nothing but charcoal and burnt earth. He says, "Whatever the people may have been, whether Amalekites or an older race, it seems nearly certain that they buried in cists, piled great cairns on the top, surrounded the whole with a stone circle in the case of more important personages, and offered sacrifices to the deceased in small open enclosures within the ring. These may probably have been the '*offerings to the dead*,' the eating of which was accounted so great a sin to the Israelites."*

Until within the last few years the only dolmens known were confined exclusively to that area of country inhabited by the Celtic race, and hence all megalithic structures were, with good reason, relegated to an origin wholly Celtic. More lately, however, since the discovery of megalithic tombs in other parts of the world, there has arisen considerable doubt as to the race affinities of the dolmen-builders; and certainly the Celts possess no traditions of the sepulchral character of these monuments, which, according to their folk-lore, were the abodes of witches and fairies, and were, according to the Bretons, the handiwork of the Korils and Teuz (elves and fays).

There are many theories as to the original home of these dolmen-building people, who have been variously named as Proto-Scythians or Proto-Celts, and as to the direction from whence they penetrated Western France and our own islands.

There seems but little doubt that their ancient seat was in Central Asia, and that they were, as M. Bertrand affirms, a conservative and exclusive race, who, resisting absorption by a superior people, were expelled from their aboriginal home, from whence they spread westward; and it is an indubitable fact that the most easterly point in Europe where their sepulchres are found is the Crimean peninsula, and that the megalithic tombs here are the most ancient of their kind known.

Thence, according to M. de Bonstetten, one branch of migration spread towards Greece, Syria, Italy, and Corsica; and another, skirting the borders of the great Hercynian forest (*via* Silesia, where at Oppeln and Liegnitz are found the next megalithic remains), took their route towards the shores of the Baltic, where the cromlechs are considered second only in antiquity to those of the Crimea.

Here there is some difference of opinion as to their line of march. According to M. Bertrand they remained for a lengthened period in Denmark, whence, again expelled, they crossed the water, and reached the Shetland and Orkney Isles, whence they can be traced on either side of the Irish Channel to Brittany, and finally re-crossed the Channel to Brittany. On the other hand, M. de Bonstetten is of opinion that from the Baltic the tide of migration overran Germany,—Friesland, Dreuthe, Schleswig-Holstein, and Jutland,—and, following the coast line, traversed Belgium, the North of France, Normandy, finally reaching Brittany, where the numerous dolmens attest their prolonged stay. Part are then supposed to have crossed over by the Channel Islands, which are rich in dolmen-mounds, to Cornwall and Devon, gradually reaching the S.E. of Ireland and Wales (the absence of such remains in the West of Ireland and in East England is very marked). Another portion left Brittany, and penetrated southwards along the coast as far as the Gironde, whence, leaving the sea-board to avoid the sandy plains of Gascony, they followed the course of the Dordogne, and traversed France in the direction of the Gulf of Lyons. Small detached bands seem also to have penetrated into Savoy and Switzerland, as shown by a few isolated dolmens in those localities. The mountains seem to have delayed the onward progress of these nomades for some time, in the Departments of Arriège, Upper and Lower Pyrenees, but, at length crossing this obstacle, they leave traces in Portugal, through Spain,—*via* Cordova, Granada, and Malaga,—and finally, crossing the Mediterranean, have left their tombs in the northern coasts of Africa, up to the very frontiers of Egypt.

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* *Vide* Palestine Exploration Fund Quarterly Statement, New Series, No. 1, January, 1871.

The African dolmens are probably the most recent, and, indeed, there are some who attribute them to the Roman period, and assert that they are due to the presence of a Roman legion raised in Armorica, who brought with them from Brittany their national customs and Celtic mode of burial; and there is a doubtful account of a dolmen in Algeria, inscribed to the memory of an Armorican centurion.

Another hypothesis, supported by Messrs. Désor and Rougemont, is to the effect that the stream of dolmen-building tribes sprang from Africa originally, and were Euskarian rather than Celtic, and poured in a northerly direction over the Iberic peninsula, and thence into France; in fact, the reverse of M. de Bonstetten's track. The evidence in favour of this last theory is only negative, relying on the absence of tradition in Africa pointing to an invasion from the north, and the Celtic tradition in Ireland that the Irish are of African origin.

For our own part, we believe the European dolmen-builders to be of a Scandinavian origin, and for this reason, that the Scandinavians have followed the ancient custom of erecting chambered tumuli to a very late period; and in their literature we find the records of their funeral ceremonies, which accord with what we should expect to find practised by the dolmen-builders. We are indebted to

Professor Stephens's work for the following translation from the "Elder Edda;"—

> "The Elder Edda."—*Sigrdrífumál*, verses 33, 34; Ed. P. A. Munch. Translation (quoted from the *Foreword* of Professor Stephens's "Old Northern Runic Monuments of Scandinavia and England.")

Rede ninth rede I thee:—
rescue the lifeless,
a-field where-er thou find them;
whether sank he on sick bed
or Sea-dead lieth,
or was hewn by hungry weapon.

O'er the breathless body
a Barrow raise thou,
hands and head clean washen;
comb'd and dried eke
in his kist fare he,
and bid him softly slumber.

The fine picture of raising the grave mound over the folk-lord, as found in our noblest English epic, "Beowulf." After his awsome *kamp* (battle) with the fire-drake, which he slays, but at the cost of his own life, the dying Wægmunding's last words are:—

My life-day's now over.
Bid my good barons
to build me a *Low*—
fair after fire-heap—
at the flood-dasht headland.
A *Minne* shall it stand there
to my mates and landsmen,
high-looming
on Hroneness.
so that seafarers
sithance shall call it
Biowulf's * Barrow,
as their beak-carv'd galleys
out of hazy distance
float haughtily by.

Further on, after some fragmentary lines describing Beowulf's (life-brand) *burning of his body* (showing that incremation was prevalent), the lay tells us:—

Gan then to make them—
those Gothic heroes—
A Low on the lithe,
lofty and broad,
by the fearless foam-plougher
seen far and wide,
till on the tenth day
towering stood there
the battle-chief's beacon.

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* Beowulf, near end of Fitte 38.

The brand-scorcht floor
a mound covered
mighty and worshipful,
as found most fitting
their famousest sages.
Within the *Barrow*
laid they beighs and ornaments,
and such driven drink-cups
as in the drake-hoard
the furious warriors
a-fore had taken.
The earth be-gem they
with Earl-sprung jewels,
fling gold on the gravel,
where again it shall lie
to all as useless
as erewhile it was.
Round the *How* rode then
those Hilde champions,
all the troop
of those twelve athelings,
their *Keen* raising,
their King mourning,
word lays chaunting
and of (Walhall) speaking.

Mr. Spence Bate attributes the presence of the numerous megalithic sepulchres and monuments of Dartmoor to the Vikings of the North, who came thither in search of tin, as testified by the enormous extent of ancient stream workings on the West Webber, under Warren Tor; and supports his theory as a philologist by an exhaustive analysis of the etymology of the names of the rivers, hills and places, fortified positions, &c., in the neighbourhood, the majority of which he traces to a Scandinavian origin.

Whether the Scandinavian Norsemen derive their blood from an Asiatic stock is a question for anthropologists to discuss.

II. THE ILLUMINATION OF BEACONS AND BUOYS.

MUCH has been done to reduce the chances of shipwreck upon our coast, always so difficult of navigation, and yet very little is generally known of the progress in the application of science to indicate to the mariner his proximity to danger. There are two ways of assisting seamen in their passage on a coast-line—by the lighthouse, of use by day and night; and by the buoy or beacon, of use by day alone. But often, and indeed in the majority of cases, the rock or projecting spit is too small and not sufficiently important to allow of the erection of a lighthouse with the necessary expensive apparatus and shelter for the keepers; some other expedient must then be found, and recourse is had to the mooring of a buoy, or the erection of a light ironwork beacon. It is evident that the value of these substitutes is but small, as they are visible by day only, and that the advantages to be derived from their illumination are all important; for it must be borne in mind that a vessel when in mid ocean is perfectly safe compared with her position when nearing the coast. The dangers, too, increase with the time of being out of sight of land, because a seaman on a long voyage may, by fogs and cloudy weather, be prevented the verification of his course by solar or lunar observations, thus rendering it difficult for him to determine accurately the situation of a dangerous point. The erection of suitable sea marks is, therefore, a matter affecting equally our foreign commerce and our coast service.

The sources of illumination for beacons and buoys, Mr. Thomas Stevenson, C.E., in his recently published work on "Lighthouse Illumination," considers the following:—

"1st. The adoption of apparent or borrowed lights.

"2nd. The use of dipping lights for indicating the position of shoals, by depressing the lamp and apparatus, so as to cover with the light the ground that is dangerous.

"3rd. The conduction either of voltaic, magnetic, or frictional electricity, or that produced by the efflux of steam, through wires, submarine, or where practicable, suspended in the air, so as to produce a spark either with or without vacuum tubes, or by means of an electro-magnet and the deflagration of mercury.

"4th. The conduction of gas from the shore in submarine pipes.

"5th. Self-acting electrical apparatus, produced by the action of sea-water or otherwise at the beacon itself, so as to require no connection with the shore."

This last method was suggested by Mr. T. Stevenson, in the "Transactions of the Society of Arts for 1866;" and it is worthy of note that Mr. A. Bain, in 1848, produced and maintained a steady light off Brighton by the use of sea-water as the exciting fluid of the galvanic arrangement.

The use of apparent or borrowed light is now, from its simplicity, almost generally known. It consists of a certain combination of prisms contained in a lantern erected on the sunken rock, for producing the divergence of parallel rays emitted by a distant lamp placed on the shore.

Thus the light seen by the seaman is merely a reflection of that on shore, the parallel rays of the shore-light being undistinguishable at the distance from which the apparent or reflected light is seen. One of these apparatus is erected at the Bay of Stornoway, a well-known anchorage in the Island of Lewis, the reflecting beacon being erected on Arnish point, a sunken reef on the south side of the entrance. This beacon is distant 530 feet from the real lighthouse, and consists of a truncated cone of cast-iron bearing the reflectors, which are exactly on a level with the window whence the light is projected. The beacon thus directly marking the spot to be avoided is only accessible at the low water of spring tides, and this is, therefore, the only kind of light available. But there are situations in which a beacon cannot, owing to a great depth of water, be erected, and it becomes necessary to ascertain whether a buoy could be employed. From experiments made on different parts of the coast, Mr. T. Stevenson finds the application would be perfectly practicable. The difficulty to be surmounted is the swinging of the buoy at its moorings; this, however, can be compensated by causing the rays from the shore to subtend a sufficient space to always include the reflectors.

The apparent light is such a marked improvement upon the dipping light, which merely illuminates the sea covering the dangerous spot, at a very small additional expense, that there can be no doubt of its substitution.

The third method of illumination, not as yet fully developed is, however, of paramount importance, as providing light for those situations where the apparent light is inapplicable. Faraday's discovery of the magneto-electric spark was first adapted to lighthouse illumination by Professor Holmes, and employed by the Trinity House in 1858, at the South Foreland Lighthouse. In 1862 this apparatus was placed at Dungeness, and here it has continued to give out its light nightly, having been extinguished on only one occasion, and then but for four or five minutes. Professor Holmes's machine consists of a number of powerful magnets, fixed into an octagonal frame. Bobbins or rods of soft iron, around which are coiled helices of silk-covered copper wire, are caused to rotate before the poles of the magnets, the result of this rotation manifesting itself as powerful electric currents in alternate directions. These currents, brought to one direction by means of a commutator, are conveyed from the machinery-room to two carbon points fixed in the lantern of the lighthouse. The carbons being raised to incandescence are gradually consumed; and this consumption is the weak point of the system, necessitating a delicate automatic arrangement to maintain a constant distance between the points. Of the merit of the light evolved, Mr. Stevenson says:—"Through the kindness of the Elder Brethren of the Trinity House, I had an opportunity of inspecting Dungeness Light after nightfall, at different distances. The weather being very favourable, there was an excellent opportunity of viewing it, and the French revolving light of Grisnez on the opposite coast. The result was upon the whole very satisfactory; the Dungeness sixth-order light, though showing continuously all round the horizon, contrasted well with the revolving, and therefore, more concentrated and first-class (oil) light of Grisnez, when viewed from a distance of about twelve miles. The electric light was generally very effective and striking in its appearance, though it frequently fell off, suffering prodigiously in volume; and once or twice it disappeared altogether for a second or two. This temporary extinction, though no doubt an evil, is not, from its very short continuance, a practical defect of any importance." But there is the important fact to be observed that the electric light appears to possess less power to penetrate the atmosphere than does the oil light. "When viewed from Dover, a distance of about eighteen miles," says Mr. W. Stevenson, "the result was decidedly in favour of Cape Grisnez." Still this loss of penetration could be compensated by increasing the original power; while it should be remembered that the order of the lamps differed greatly. Electric lamps for lighthouse purposes, moreover, are generally of too small dimensions, and hence, as the angle of divergence of the rays within the apparatus must be larger, any variation of the carbon-points from the true focus will give rise to a more extensive displacement of the emergent rays than would be the case with lamps of the size used for the oil light. In furtherance of this view, Messrs. Stevenson, in their Report of November 27th, 1865, to the Northern Lighthouses, recommended the adoption of apparatus of the third and fourth orders as being preferable to that of the sixth. This would entail some alteration in the form of the lenses in order to produce a greater amount of vertical divergence.

The penetrating power of the electric light is not, however, a question that need be raised in its application to the illumination of buoys and similar surface sea-marks; for it is generally sufficient that their light should be seen at a few miles' distance. But there is a corresponding difficulty. Neither Holmes's nor Wilde's machine can be employed, because, as the light is produced by the rapid consumption of the carbon-points, there is involved the requirement of lamp machinery too delicate to withstand the buffets of the waves. Mr. Stevenson therefore decided on the employment of vacuum tubes, or the electric spark without carbons. In order to increase the intensity of the light, Professor Swan suggested the use of a Ruhmkorff's induction coil and condenser. From the experiments instituted between the 2nd and 13th of January, 1866, Mr. T. Stevenson deduced some important results, which were communicated to the Royal Scottish Society of Arts. Platinum electrodes were employed, and the primary current was kept passing for a week without any sensible waste of the metallic points. To put these results into practice was the next step, and a submarine cable was procured by the Commissioners of Northern Lights. But the conditions of working a cable were not so well known as now, and the intense secondary current could not be made to take the desired path. Mr. Siemens was then appealed to, and he submitted a very ingenious device by which the *extra current,* as it is called, from the coils of an electro-magnet, situated at the buoy or beacon, in the primary circuit, was utilised in the production of the spark. The electro-magnet was made to work its own contact-lever, and the luminous effect was increased by forming one electrode of a vessel of mercury, renewed by the action of the electro-magnet on a small pump. This arrangement was placed at Granton Harbour, and although the light was vivid and the current easily managed, insuperable difficulties arose from the deposition of mercurial vapours upon the apparatus. Experiments with the induction-coil were, therefore, resumed, and following some improvements suggested by Professor P. G. Tait, were attended with success. The battery and break were retained on shore at Granton pier-head, while the cable extended a distance of half-a-mile to Trinity Pier, where two induction coils with condensers and the optical apparatus were placed. The coils together contained about eight miles of wire, and the spark was induced by sixteen Bunsen elements, two additional cells being used for working the break. The light was very vivid and striking. With the exception, however, of some enquiries made by the Trinity House, which led to the repetition of the experiments in 1869, to the present nothing has been done, although the recent improvements in electrical apparatus would certainly warrant the endeavour to bring this source of illumination into practice. The greatest obstacle to the adaptation is in the case of floating buoys, where the cable would be subject to abrasion against the sea bottom, in situations where the light would be most useful, always of the worst kind. Yet the wear could be brought, as we know from experience with telegraph cables, within such limits as would be practically reparable. Recent experiments with Wilde's magneto-electric machine without carbons have been made with much better results. From various trials Mr. Stevenson has also found that the most brilliant light is obtained when bismuth points are employed.

The remaining source of illumination is that by gas. In 1853, Admiral Sheringham illuminated a buoy in this manner off Portsmouth. The gas was conveyed as far as possible in iron pipes, the conduction being continued through a gutta-percha tube to the beacon. The gas was lighted by means of a platinum wire rendered incandescent by the passage of a voltaic current from a small battery on shore. The results, however, were not published till quite lately.

A beacon on the Clyde, near Port Glasgow, was, in 1861, lighted with gas, and has since been maintained. This beacon is 300 feet from shore, and the supply of gas is regulated in a very ingenious manner. A float is so arranged in the principal burner that a certain pressure is requisite to admit of the passage of the gas, consequently, when the gas is shut off from the main each morning, the light would be completely extinguished were it not for a small burner that, being fed from a gas-holder of about ten cubic feet capacity, situate in the body of the buoy, remains alight all day. Again, each night as the pressure increases, the float closing the supply-tube to the principal burner rises, and the beacon is fully illuminated. The objection to this system, however, is the liability of the flame to extinction—a risk from which the electric spark is free. The accumulation of water in the pipes is another serious obstacle; while in the case of electricity the risks of faulty insulation would be compensated by the use of duplicate wires.

These numerous experiments, however, go far to prove that the illumination of buoys and beacons from the shore is perfectly feasible, and the time is not perhaps very distant, when, following the suggestion of Messrs. Stevenson, the entrance to the Port of Liverpool, for example, will be lit up from either shore by apparatus easily managed by one or two men. The illumination of Arnish Point by the apparent light for eighteen years, and the conveyance of gas under water at the Clyde for nine years, in both cases with very slight repairs, are facts demanding a more general extension of these principles. It is no longer a question of expense, as in the erection of the Eddystone and Bell Rock Lighthouses, but an easy expedient calling for speedy recognition. While there are many situations where it would be impossible at any expense to construct a lighthouse, these generally admit of the employment of one of the apparatus described, and which would be equally efficacious. The good done by the erection of our lighthouses in the saving of life and property is almost incalculable, and is fully an encouragement to proceed with the illumination of the smaller sea-marks.

III. NATURAL AND ARTIFICIAL FLIGHT.

ARTIFICIAL flight is by no means an idea of mediæval or of modern times. Setting aside its consideration as a poetical and legendary attribute, there are tolerably authentic accounts, if not of the actual flight of man, of the imitation of the movements of birds in well-constructed automata. Archytas had a wooden dove capable of flight, and Regiomontanus made a wooden eagle. These, however, are merely historical records, and there are not many definite plans left to us until 1683, when Wilkins, Bishop of Chester, published his plans of an aërial chariot. From that time to the present hardly a year has passed without the appearance of some proposal, more or less visionary, to solve the problem of aërial navigation. But these proposals have only resulted in ignominious failure, sometimes fatal to the experimenter; and this is hardly a matter of wonder when we consider that, for long, little or nothing was known of the laws of gravitation and of the medium to be controlled. The methodical study of the laws of the natural flight of birds and insects has been neglected even up to the present time. It is, then, hardly just to condemn the student of aëronautics as one needing friendly care, until a complete series of experiments, conducted according to the light of present science, shall have shown the futility of the idea of artificial flight. It was an intention of research that called the Aëronautical Society into life, five years ago, and although the Society has not, as a body, undertaken experimental investigation, individually there has been much done to prevent wasteful work, to point out essential principles, and the causes of failure hitherto. But the thanks of the Society are mainly due to MM. Marey and De Lucy, who, by their able investigations of the laws of natural flight, have done much to elucidate the subject.

Aërostation may be considered under two heads. 1. Ballooning, in which ascent is gained by means of a gas specifically lighter than air. 2. True flight, in which the acts of rising and suspension are due to expended force. There are two obvious reasons why balloons have not been successfully navigated. It is difficult to apply a directive force at the point of suspension of the balloon, while any force applied to the car merely serves to tilt the balloon. Again, a body to be propelled against a current of air, even that created by its own motion, must have a weight in proportion to its surface. This law will become apparent in endeavouring to throw a block of wood and a cube of paper to the same distance.

It was for long generally supposed that birds were suspended or balanced by a certain volume of rarefied air confined in the lungs, bones, and feathers. But this explanation will not bear the least reflection, for (the density of the air being 781 times less than that of water) a bird weighing a kilogramme, together with its wings, cubes about 4 decimetres, and can therefore only displace 4 decimetres of air, the weight of which is 5 grammes 20 centigrammes. Hence it follows that a raven weighing 1 kilogramme, to be supported in the air, should have a volume of at least a cubic metre.

In considering the phenomena of flight it is necessary, then, to observe the weight, or gravitating force, the surface or resistance of the air, and the force of projection. The point immediately presenting itself, under this consideration, is the determination of the relation of the extent of wing-surface to the weight of the bird. This question gave rise to much controversy amongst naturalists, until M. de Lucy undertook its settlement by a series of decisive measurements. He sought to establish a common unit between birds and insects in this matter, and, although here not perfectly successful, the experiments clearly proved that birds of large size and great weight are sustained by a much smaller proportional wing-surface than those of smaller size. If the wing is considered as the means of elevation, that is, as an instrument with which to strike the air, and thus derive a power of ascension, there are geometrical reasons why the greater weight of the larger bird should not have a proportional wing-surface. Consider two objects similar in shape,—for instance, two cubes,—one having twice the diameter of the other, then each of the faces of the larger cube is four times the size of each face of the smaller cube, while the larger cube has a weight eight times that of the smaller. This is but a familiar illustration of the fact that all geometrical solids with linear dimensions, bearing a stated relation, have their surfaces proportioned as the square, and their weight as the cube, of their similar linear dimensions. So that two birds of the same form, but one having a width of wing from tip to tip twice that of the other, will have their wing-surfaces proportioned as 1 : 4, and their weight as 1 : 8. Applying these principles, Dr. Hureau de Villeneuve has endeavoured to determine the extent of wing that would enable a bat of the same weight as a man to fly, and he has found that each of its wings would be less than three metres, or a little more than three yards, in length.

The most important points in the consideration of the ultimate capability of man's flight still remain. They are—can man exert sufficient force? and can that force be mechanically employed to raise himself from the ground? The second of these questions is yet to be answered; the first has been solved by the experiments of M. Marey, of the College of France. It is evidently only necessary to consider the power of a bird to raise its own weight, because, when once in the air, by the simple extension of its wings, the bird is converted into a natural parachute, counteracting the direct action of gravity, so that it does not acquire even the descending velocity of nearly 17 feet in the first second, but traverses a much less space,—in fact, a space that does not increase as the square of the time. Therefore it follows that a bird has not, as calculated by Borelli and Navier, to employ force to counteract gravitation, because it finds a counter-balance in the resistance of the air. The force, then, to be expended is only that necessary to prevent the fall for a fraction of a second. Now, M. de Lucy asks, what is the space traversed in one-tenth of a second by a body left to itself? This space is 19·29 inches; but as a bird is supplied with a large surface of suspension the space may be estimated as much less, or at 25 centimetres, in English measure 9·84 inches. The bird, then, has to expend a force sufficient to raise itself, say a weight of 1 kilogramme, or about 2¼ lbs., 9 or 10 inches at each flapping of the wing. Now, supposing ten strokes of the wing to be made per second, the total force expended per second amounts to 2 or 3 kilogrammetres. But as between each stroke of the wing there lapses one-tenth of a second, during which the bird does not fall, but elevates itself under the impulse that is given to it, five strokes of the wing are sufficient, and the force required will be only 1 or 1½ kilogrammetres. Now these hypothetical calculations are very closely related in result to the direct anatomical investigations of M. Marey, who found, by exposing the great pectoral muscle, and exciting it electrically to cause motion, that the force of contraction supported a weight of 2 kilogrammes 380 grammes. Admitting that the electrical agent cannot produce so powerful a muscular contraction as that called forth by the will, and doubling or quadrupling the results obtained, there still does not result the force that Koster attributes to the muscle of man. Hypothetically, a bird capable of sustaining itself must expend a force proportional to its weight, and consequently ought to possess a proportional weight of muscle. This has been found experimentally true, and it appears, from the researches of Hastings, published in the "Archives Neërlandaises" for 1869, that the weight of the pectoral muscle is about one-sixth of the total weight of the bird. It would, therefore, be a natural conclusion that we should admit the wings of birds to possess the same velocity, and from this point of view the duration of the stroke will increase with the linear dimensions of the bird,—that is, large birds will make fewer strokes than small ones. M. Marey has invented a novel and most ingenious apparatus for the measurement of the frequency of the strokes of the wings of a bird, and the relative duration of the periods of elevation and depression. By his method the bird is made to record the movements of its wings, by the swelling of its pectoral muscle as it contracts to draw the wings downward. The bird flies in an inclosure 15 metres square and 8 metres high. The registering apparatus (Fig. 1) consists of a revolving blackened cylinder, upon which a style traces a crenulated line corresponding to the motions of the wings. A double connection is established between the bird and the registering apparatus; one by electricity, conveyed through two fine wires to contact points fastened to the wing of the bird; the other by flexible India-rubber tubing, about 12 metres in length. This apparatus is applied to a pigeon by means of a corset. Under this corset, between it and the pectoral muscle, is placed a small, shallow metal basin, containing a spiral spring, and covered by a thin sheet of rubber (Fig. 2).

Any pressure applied to the rubber forces the air out of the basin into the tube, and if the pressure ceases the air re-enters the basin, in consequence of the elasticity of the spring. The registering apparatus comprises a similar basin, to the rubber of which is attached a lever carrying a tracing-style. The motion imparted to the first basin is transmitted, by the air confined in the India-rubber tube, to the membrane of the receiving apparatus. In employing India-rubber tubing it is necessary to prevent the elongation of the tube by its own weight as the bird rises in the air, as the elongation would cause a rarefaction of the air in the interior of the tube, and consequently interfere with the signals recorded. The bird is thrown off at one end of the enclosure,, the dovecote in which it is ordinarily kept being placed at the opposite end. The bird, in endeavouring to

FIG 1.

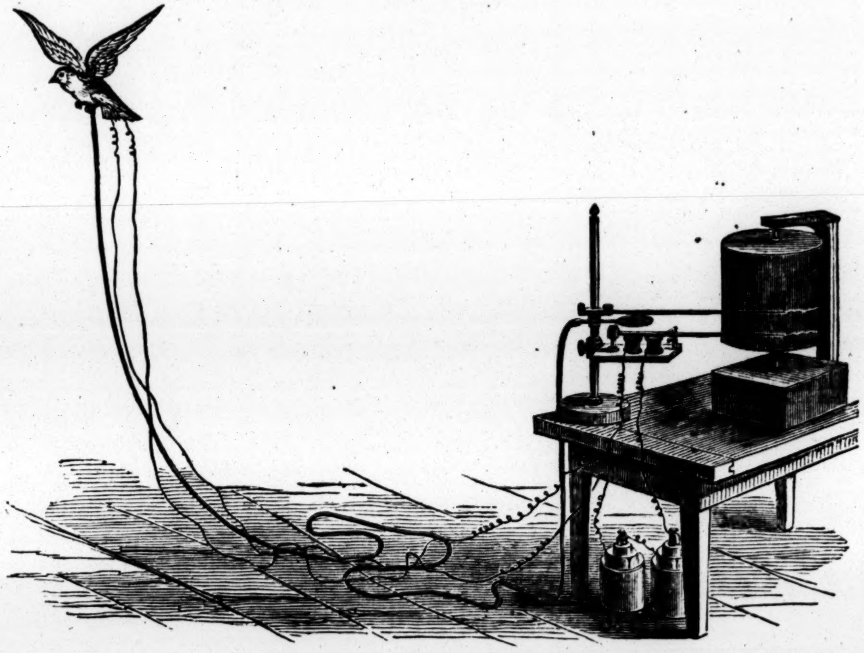
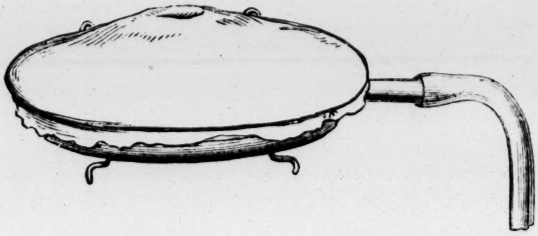


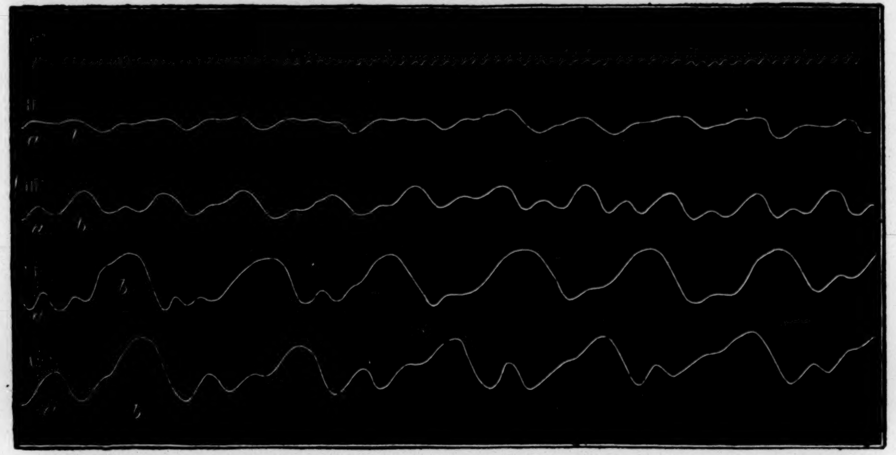
FIG. 2.



reach its cote, causes the traces on the blackened cylinder shown in Fig. 3.

The tracings vary with the kind of bird placed in the corset; but in all may be seen the alternation of two motions, *a* and *b*, produced during each vibration of the wing, that of *a* corresponding to the action of the muscle elevating the wing, and that of *b* to the muscle depressing the wing, Anatomically, *a* shows the swelling of the median pectoral, and *b* that of the great pectoral. Nothing more should be expected from these tracings than they naturally furnish, that is to say, the number of vibrations of the wing, the greater or less regularity of its movements, the equality, inequality, and energy of each of them. Confining the investigation to these limits, we obtain the following results:—

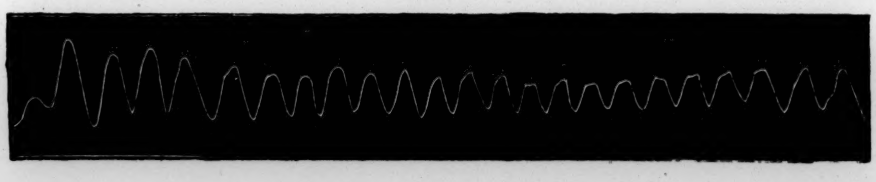
FIG. 3.



Tracings of the Expansion of the Pectoral Muscle of Various Birds during Flight.

I. Tracings of a Tuning-Fork making 200 vibrations a second. II. From the muscle of a Pigeon. III. From a Wild Duck. IV. From a Hen Hawk. V. From a Harrier.

FIG. 4.

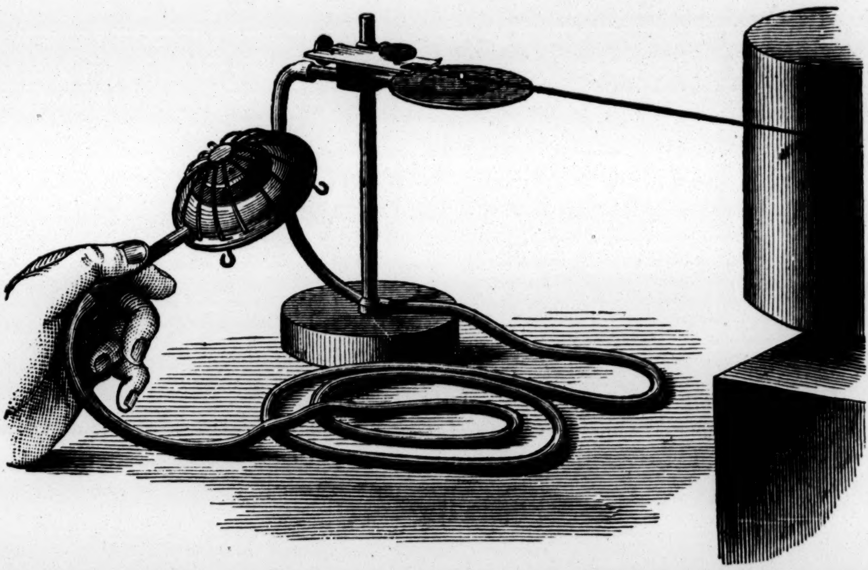


	Number of Wing Vibrations per Second.
Sparrow	13·00
Wild duck	9·00
Pigeon	8·00
Buzzard (*Buteo vulgaris*)	5·75
Screech owl	5·00
Harrier (*Circus rufus*)	3·00

At the commencement of the flight the strokes of the wings are fewer, but more energetic; in mid-flight they attain a regular rhythm, becoming again irregular at the moment of the descent of the bird. Fig. 4 shows the difference in amplitude and frequency of the wing-strokes of a pigeon during a flight of 15 metres. The extended tracings to the left indicate the movements at the commencement of the flight. A glance at the preceding table will be sufficient to show that Nature has here established a compensation for the diminutiveness of the organs of the smaller birds by rapidity of movement.

To complete the series of investigations M. Marey studied the phenomena of natural flight, not analytical as hitherto, but as a whole. During flight two distinct effects are produced,—the bird is upheld against the force of gravity, and it is propelled horizontally. And now arise the questions:—Is the bird sustained at a constant elevation, or does it oscillate in a vertical plane? Is there a series of altations and depressions, the amplitude and occurrence of which cannot be observed by the eye? Is there any variation of velocity in the horizontal course? Does the action of the wings impart a jerking motion? These questions are of the greatest import, if we observe the flight of birds with the view of applying the laws discovered to the subject of the artificial flight of man; and although some of them might have been answered by deductions from the result of preceding experiments, there can be no doubt of the correctness of

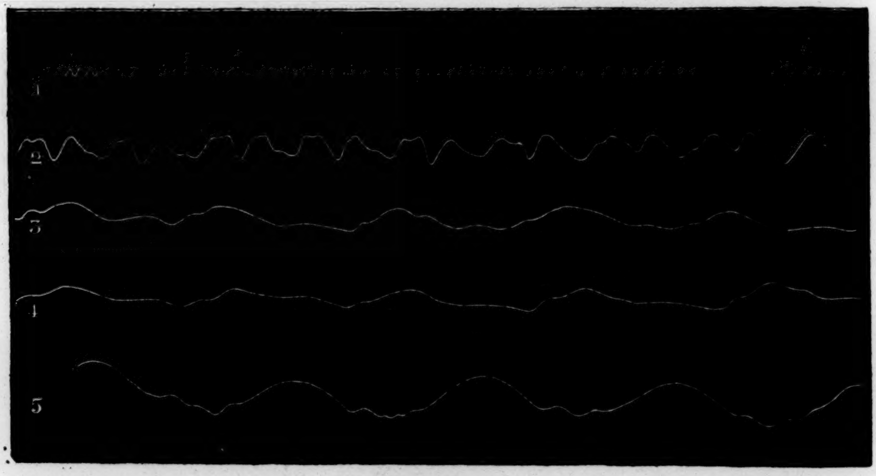
FIG. 5.



M. Marey's decision to still further investigate, and to depend on experimental results alone. The laws that might be deduced involve in their deduction such complicated calculations that it would be easy for an error to creep in. Besides, possessing the means by which distant motions can be registered, or rather caused to register themselves automatically throughout their whole amplitude, the experiment becomes a matter of no great difficulty. The problem to be solved is that of so arranging the membrane of the apparatus shown in Fig. 1 as to record the bird's rise and fall in a vertical plane,—that is to say, the rise and fall of the bird should produce a varying pressure on the membrane of the metallic drum. Supposing that a flying bird carries on its back a drum of the form described, with the membrane uppermost,—if this membrane follows the motion of the bird there will be no displacement of the air in the apparatus, and the style will remain motionless. But if the membrane is prevented from following the motions of the bird; if there can be given to it a tendency to remain at rest, while the body of the drum attached to the bird is moved, the air in the apparatus will be compressed or rarefied, and motion imparted to the registering style. This tendency can clearly be produced by loading the membrane with an inert body, such as a disc of lead. Fig. 5 illustrates this; the drum is seen attached to the registering apparatus, with the inert mass, the disc of lead, upon the membrane. Practically there are several discs, which may be added or removed as the exigencies of the experiment require. The movements in the horizontal direction are not registered, because elevation and depression can alone affect the inertia of the leaden discs, for when the bird ascends the inertia of the mass resists the upward movement, and causes a record similar to that which would have taken place had the membrane itself been subjected to pressure, and the drum had remained motionless. To protect the apparatus from accidental pressure by the wings of the bird, a wire cage was employed. There is, however, still the objection that an inert mass placed on an elastic membrane may execute vibrations peculiar to itself, and that the apparatus will record these vibrations, as well as the oscillations of the bird. How can this complication be removed? The law of vibrations teaches that the greater the mass, and the feebler the elasticity, the longer will be the period of vibration. Then as the motions we are studying are tolerably frequent, if we arrange matters so that the vibrations of the disc shall be of a longer period than the oscillations of the bird, we get rid of the difficulty.

Experiments with several birds—ducks, harriers, hen-hawks, and owls—have shown that, in relation to the intensity of the oscillations in the vertical plane, very varied types exist. Fig. 6 shows tracings furnished by these birds. The upper crenulated line is produced by a tuning-fork vibrating 100 times per second. Thus the tracings may be estimated absolutely, or in relation to each other. A still clearer view will be obtained of the actions, during the bird's flight, if the oscillations of the bird vertically and the movements of its muscles are recorded at the same time. The tracings represented by Fig. 7 will then be obtained. The duck presents two energetic oscillations at each revolution of its wing; the one at *b*, at the moment when the wing relaxes, is easily understood; the other, at *a*, at the moment when the wing rises. To explain the ascension of the bird during the time of the elevation of the wing, it seems to me, says M. Marey, indispensable to call in the action of a boy's kite. The bird, moving forward with acquired velocity, presents its wings to the air in an inclined position, similar to that of the kite, and thus transforms its horizontal force into an ascending one.

FIG 6.

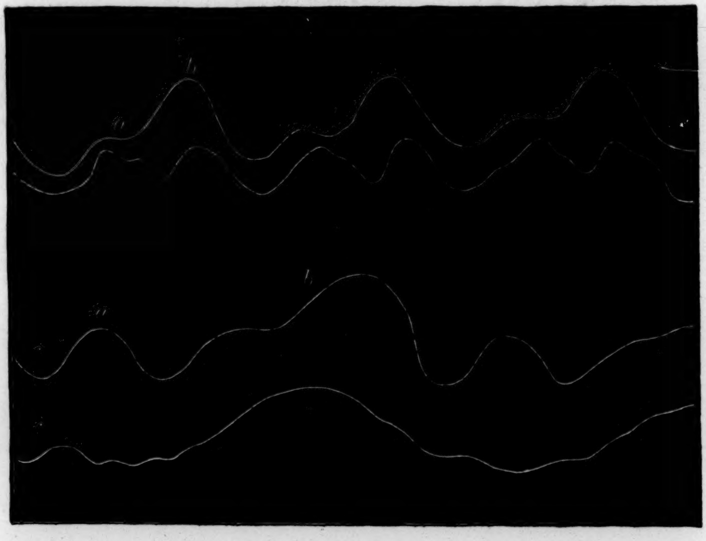


Tracings.

I. From the Tuning-Fork. II. Wild Duck. III. Buzzard. IV. Screech Owl. V. Harrier.

The preceding experiment furnishes a very precious lesson in the theory of flight. In fact, if the bird executes a series of ascents and descents, the duration of the descending period will approximately inform us of the amount of positive work which the bird must perform to rise again to the height from which it fell; and we see that the duck, which makes nine vibrations of the wing per second, executes two vertical oscillations during each vibration, or eighteen in a second. Each oscillation is composed of a rise and a fall, so that each descent of the bird cannot last more than 1-36th of a second. Now, if we subtract the effect produced (as in a parachute) by the outspread wings of the bird, we find that a body which falls during 1-36th of a second traverses only 52 millimetres. This fall, repeated eighteen times a second, constitutes a total rise of 9·36 centimetres, necessary to maintain the bird in the same horizontal plane during one second. In the tracings of the harrier the descents are less than in that of the wild duck, probably on account of the large surface of the wings of this bird.

FIG. 7.



The two upper lines are the muscular tracing and the tracing of the oscillations of the duck. The lower lines are tracings from a harrier. Underneath the undulation *a*, indicating the elevation of the wing, is seen a vertical oscillation; and again beneath *b*, indicating the lowering of the wing. The oscillation at *a* in the lower tracings of the harrier, corresponding to the elevation of the wing, is less marked than in the duck.

The remaining question to be solved relates to the determination of the phases of rapidity of flight. The solution can be found by placing the weighted drum vertically upon the bird's back. The tracings furnished are, however, so analogous to the oscillations in the vertical plane, that they show very little more than a proof that during the descent of the wing the speed of the bird is accelerated.

At last, then, we are in possession of the principal facts upon which the study of the mechanical power developed by the bird during flight can be established, and we see that it is during the descent of the wing that the entire motive force which sustains and directs the bird in space is developed. We have also seen that man possesses the requisite strength to raise himself, could the mechanical means be devised. What has been effected by the mechanical means already devised? Almost nothing, for so little has been done upon principle. The "Chalon" machine, drawings of which were exhibited some time since at the Aëronautical Society's meetings, appeared as one of the best perfected schemes,—consisting in elevation primarily by means of gas, wings then giving control to the machine. But even in this case the relative proportion of surface to weight was overlooked; it would be almost impossible to direct such a machine against the wind. It follows, evidently, that if gas is to be employed as a means of elevation, when elevation is attained some other agency must take the place of gas. Perhaps the machine attended with the greatest practical success has been that of Mr. Charles Sinclair, who managed to raise himself some 15 feet in the air without the assistance of a specifically lighter material. His plan consisted in fastening to the body of the aëronaut a series of parallel aëro-planes, somewhat similar to a set of shelves made of light frame-work, covered with canvas, and arranged at about 2 or 3 inches from each other. Running against the wind with these quasi-wings attached to his body, Mr. Sinclair, in his first experiment, found himself elevated a few feet, when one of the planes shifted, and he was violently hurled to the ground. The machine mended, with several improvements in its construction, he again essayed to attain some slight elevation, and, with a preliminary run of 100 feet, rose steadily in the air to a height of 15 feet. This experiment would seem to point to some modification of a boy's kite as a means of elevation. Anyone who has seen a Canadian ice-boat has observed how, at the slightest check, such as that afforded by a small block of ice, the vessel is raised by the force of the wind upon the sails, and carried over the impediment. Similarly the boy runs with his kite to raise it; but we must seek some other means of imparting the required momentum, probably by the inclined plane for that afforded by running. Until some motor is found capable of working in a small compass, and with a moderate weight of fuel, the idea of flying by the aid of extraneous machinery must be given up, and man must trust to his own strength. But, despite failures, there can only be offered to aëronauts an argument similar to that offered to Watts and Stephenson,—"Man never has flown,"—but we must stop short of saying—"and he never will."

IV. THE COAL COMMISSIONER'S REPORT.

THE question which gave rise to the appointment of the Royal Commission, whose Report* we are now about to review—namely, the probable duration of the coal resources of the United Kingdom—was, according to Mr. Jevons's account,† first raised by one John Williams, a mineral surveyor, who, in a work published by him in 1789, entitled "Natural History of the Mineral Kingdom," gave a chapter to the consideration of "The Limited Quantity of Coal of Britain." At that time the coal production of the United Kingdom amounted only to about 7,500,000 tons annually. This subject was also referred to by Sir John Sinclair, in his "Statistical Account of Scotland," and again in 1812, by Robert Bald, "in his "General View of the Coal Trade of Scotland." Later still, Dr. Buckland prominently brought it before the public, both in his evidence before the Parliamentary Committees of 1830 and 1835, in his "Bridgwater Treatise," and again in his address to the Geological Society, on the 19th of February, 1841. Up to this time, however, the public generally did not express any great interest in the matter; and it was not until the publication of Mr. Hull's work‡ on the subject, in 1861, that its real importance began to be better appreciated. This was shortly afterwards followed by Sir William Armstrong's celebrated address as President of the British Association, at Newcastle, on the 26th of August, 1863, in which he stated that "the entire quantity of available coal existing in these islands has been calculated to amount to about 80,000 millions of tons, which, at the present rate of consumption, would be exhausted in 930 years; but, with a continued yearly increase of 2¾ millions of tons, would only last 212 years." This announcement, by which the real importance of the question was put before the public in a practical shape, caused at the time considerable excitement throughout the country; and it soon became clear that some confirmation or refutation of the statistics first published by Mr. Hull in his work above referred to, and subsequently promulgated by Sir William

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* Report of the Commission to Inquire into the several Matters relative to Coal in the United Kingdom, July 27, 1871.

† The Coal Question: an Inquiry concerning the Progress of the Nation, and the Probable Exhaustion of our Coal Mines. By W. STANLEY JEVONS, M.A., &c. 1866.

‡ The Coal Fields of Great Britain. By EDWARD HULL, B.A. 1861.

Armstrong, was desirable in the public interest. On the 12th June, 1866, the subject was brought before the House of Commons, by Mr. Hussey Vivian, in a very able speech, in which he moved for the appointment of a Royal Commission to inquire into several questions connected with the coal resources of the United Kingdom. This motion was agreed to, and on the 28th idem, the Commission was accordingly appointed, consisting of fifteen members,* with the Duke of Argyll as chairman.

The special instructions to the Royal Commission were as follows:—

"To investigate the probable quantity of coal contained in the coal-fields of the United Kingdom, and to report on the quantity of such coal which may be reasonably expected to be available for use.

"Whether it is probable that coal exists at workable depths under the permian, new red sandstone, and other superincumbent strata.

"To inquire as to the quantity of coal at present consumed in the various branches of manufacture, for steam navigation, and for domestic purposes, as well as the quantity exported, and how far and to what extent such consumption and export may be expected to increase.

"And whether there is reason to believe that coal is wasted by bad working, or by carelessness, or neglect of proper appliances for its economical consumption."

The first act of the Commissioners was to form amongst themselves five committees for the following purposes:—

1. A. Committee on possible depths of working.
2. B. Committee on waste in combustion.
3. C. Committee on waste in working.
4. D. Committee on the probability of finding coal under permian, new red sandstone, and other superincumbent strata.
5. E. Committee on mineral statistics.

Without confining ourselves in any way to the order in which these Committees subdivided the several questions submitted for their investigation, we now proceed to give briefly the results arrived at by them, and which have been embodied in their respective reports, or brought out in the evidence taken by them.

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* Sir R. J. Murchison, Sir W. G. Armstrong, Messrs. H. H. Vivian, G. T. Clark, J. Dickinson, G. Elliott, T. E. Forster, J. Geddes, R. Hunt, J. B. Jukes, J. Hartley, J. Percy, J. Prestwich, A. C. Ramsay, and J. T. Woodhouse.

There is but little reason for doubting that British coal was used in small quantities in the days of the Roman occupation of these islands, as it has been found amidst the remains of Roman civilisation in the city of Uriconium and elsewhere. Statements respecting the use of coal before the twelfth century are, however, exceedingly fragmentary; since that period there is tolerably ample information to be obtained respecting the coal trade from the rivers Tyne and Wear, but very little relative to the production at this period of coal in other parts of the kingdom. The first record dates back to the year 1180, when Bishop Pudsey, of Durham, granted some land to a collier, to provide coals for a smith at Coundon, in the county of Durham; similar grants being also made at Sedgefield and Bishop Wearmouth. In 1213, a charter was granted by King John to the men of Newcastle to dig coal. The earliest record of coal being used in the South of England is in 1279, when coal was purchased at Dover for the use of the castle. In the year 1300, coal was used in quantity by the brewers and smiths of London; which was, however, prohibited in 1306, on the ground of its being an intolerable nuisance, but fifteen years afterwards it was used in the royal palace. The first Government tax was laid on coal as early as 1379, amounting to two-pence for every chalder;* but in the reign of Elizabeth it was raised to twelve-pence per chalder, which was regularly enforced to the time of Charles II. Duties were laid on sea-borne coal to assist in building St. Paul's church and fifty parish churches after the great fire of London; and in 1677, Charles II. granted to his natural son, Charles Lennox, Duke of Richmond, and his heirs, a duty of one shilling a chaldron on coals, which continued in the family until it was purchased by Government in 1799, for the sum of £400,000. This impost was known as the "Richmond shilling," and produced soon after it came into the hands of the Government £25,000 a year.

The practice of coal mining had arrived at such a degree of importance at the beginning of the eighteenth century, that we find treatises published as guides to the system of exploration. Many of the collieries were then extensive, and accidents were not unfrequent. An account is given by one author † of a "blast" which occurred in October,

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* This was probably the Newcastle chalder, containing 53 cwts. of coal.

† The Compleat Collier: or the whole Art of Mining and Working Coal Mines, &c., as is now used in the Northern Parts, especially about Sunderland and Newcastle. 1708.

1705, when "there was above thirty persons, young and old, slain by a blast, perhaps in less than a minute's time."

In 1771 there was formed a combination among the coal owners who shipped their coal by the three rivers, the Tyne, the Wear, and the Tees, to raise the price of coals to consumers by restricting the quantity supplied. This combination, known as the "limitation of the vend," lasted, with but a few temporary interruptions, until 1845. As this restriction did not apply to coal shipped to foreign parts, it frequently happened that coal was sold to foreign markets at 40 per cent under the prices in the London market. About 1791 a feeling grew up in favour of obtaining coal from the midland and other coal-producing counties for the London market.

Coal was first worked in Cumberland, at Whitehaven, by Sir John Lowther in 1660, but there does not appear to exist any record of the quantity raised until towards the end of the 18th century. Little appears to be now known of the early history of the Lancashire coal-fields. In the Cheshire coal-field, coal is said to have been first opened in Nerse township in 1750. The early history of coal mining in Yorkshire is very obscure; but it is stated in an early number of the "Leeds Intelligencer," a local newspaper, that in 1752 a petition was prepared for Parliament for rendering the Calder navigable, the chief object being the conveyance of coal. The Derbyshire coal-fields are referred to by Pilkington,* who wrote in 1789; and Cambden, in his "Natural History of Warwickshire, A.D. 1730," was perhaps the first to record any facts relative to what is known as the Staffordshire coal district. Shropshire from a very early period appears to have yielded from its stores fuel for the use of man. Shropshire coal has been found in the ruins of Uriconium. The earliest record of any colliery workings in this county however, appear in the "Leeds Intelligencer" for November 23rd, 1756. The first notice of the production of coal in the Forest of Dean appears to be supplied by the records of the Justice Seat held at Gloucester in 1282, where it is stated that sea coal was claimed by six of the ten bailiffs of the Forest of Dean. Coal was sent to London from South Wales as early as 1745, and in North Wales the Mostyn Collieries date from the 23rd year of the reign of Edward I. Amongst the earliest reliable accounts of the Scotch coal-field, we find that in the twelfth century,

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* A View of the Present State of Derbyshire, with an Acconnt of its most Remarkable Antiquities, &c. By JAMES PILKINGTON. Derby, 1789.

William de Vetereponte granted to the monks of Holyrood, "totam decimam de carbonaris meo de Carriden." This is the name of a small brook flowing into the Firth of Forth, about three miles north of the ancient palace of Linlithgow. This was in the time of William the Lion, during whose reign the monks of Newbattle worked coal on the margin of the Esk. Arthur Dobbs, author of an "Essay on the Trade of Ireland," writing in 1728, says, "We have of late discovered coal mines in the counties of Cork and Leitrim."

Having thus, in the briefest possible manner, touched upon the early history of the coal-fields of the United Kingdom, we pass on now to notice the amount of coal that has been raised from time to time. The estimated production of the whole kingdom is thus given in the Commissioner's Report:—

"In the three centuries before 1800, it is computed that not less than 850 millions of tons of coals were raised from the coal-fields of the kingdom. During the next fifty years there was a constant and steady increase in the production, and fully two thousand millions of tons of coal were extracted. Up to this time the records of coal produce were most imperfect, and it was not until the year 1854 that reliable returns have been in existence. The average production in 1851, 1852, and 1853, may be taken at 50,875,000 tons per annum. In the years 1854 to 1869, both inclusive, 1,343,793,705 tons were raised, which added to the figures above given, and estimating the return for 1870 at 110,000,000 tons, show that we have already drawn from our original stores of fuel not less than 4,456,000,000 tons* of fuel."

Space will not admit of our entering into any minute detail regarding the consumption of coal, but it may be stated that, of the 107½ millions of tons raised in 1869, 32,446,506 tons were employed in iron manufacture; 25,327,213 tons in manufactures; 3,277,562 for steam navigation, 2,027,500 for railways, locomotives, &c.; 18,481,572 in domestic consumption; and 9,775,470 tons were exported.

Large portions of some of our coal-fields lie at a greater depth than has yet been reached in mining, and it is considered that the increase in temperature which accompanies increase of depth is the only cause which it is necessary to consider as limiting the depths at which it may be practicable to work coal. In this country the temperature of the earth is constant at a depth of about 50 feet, and at that depth the temperature is 50° F. The rate of increase of the temperature of the strata in the coal districts of England is in general about 1° of Fahrenheit for every 60 feet of depth. The depth at which the temperature of the earth would amount to blood heat, or 98°, is about 3000 feet. Under the long wall system of working, a difference of about 7° appears to exist between the temperature of the air and that of the strata at the working faces, and this difference represents a further depth of 420 feet; so that the depth at which the temperature of the air would, under present conditions, become equal to the heat of the blood, would be about 3420 feet. Beyond this point the considerations affecting increase of depth and temperature become so speculative as to render it necessary to leave the question in uncertainty; but, looking to possible expedients which the future may elicit for reducing the temperature, it is considered that it may fairly be assumed that a depth of at least 4000 feet might be reached.

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* The Report says 4300 millions of tons, but in this figure the returns for the three years 1851 to 1853 appear to have been omitted.

Before considering the supplies of coal which still remain for consumption, within a workable depth, it is necessary to refer briefly to the waste that now occurs in working, and through imperfect combustion.

The theoretical value of 1 lb. of coal is 14,000 units of heat, which, if properly applied, should be equal to the power of lifting 10,800,000 lbs. 1 foot high, whilst the highest practical result which has been realised is 1,200,000 lbs., or less than one-eighth of the theoretic value, and this without counting the impurities of ordinary coal, which cannot be taken at less than 10 per cent. *Theoretically*, 1 lb. of pure coal should evaporate about 13 lbs. of water; *practically*, 1 lb. of ordinary coal does not evaporate 4 lbs. The best results are stated to have been obtained in the boilers of Cornish engines, or in boilers constructed upon the model of the "Cornish boiler." The "duty" of the best Cornish engines since 1814 shows that, up to a certain point, there was a gradual increase in the number of pounds lifted 1 foot high by the combustion of 1 bushel (94 lbs.) in the earlier tables, and of 1 cwt. (112 lbs.) in the latter ones; and that, after the maximum had been obtained, there was a steady decline in the effective power obtained; but the highest recorded duty is about 98,300,000, in 1857. Upon the general question of coal consumption, the conclusion arrived at by the Commission is, that "for some time past, in our manufactures, there have been constant and persevering efforts to economise coal, by the application of improved appliances," and there is reason to believe that, "in some branches of manufacture, the limits of a beneficial economy appear to have been nearly reached, and that in other cases a gradual effort would continue to be made for saving fuel." It may be assumed, therefore, that the progress of economy in using coal is not likely to operate in future with greater effort in keeping down the increase of consumption than it has hitherto done. The present consumption of coal for domestic use is generally estimated at 1 ton per head of the whole population, and the future increase under this head may be expected to coincide with the increase of population; whilst, as regards the future exportation of coal, there is reason to doubt whether much further increase will take place in this direction, owing to the steady development of the coal-fields in other countries.

With regard to the available supplies of fuel yet remaining, a not unimportant consideration is the amount of waste incident to mining coal. It is clear, from the evidence adduced on this subject, that, although in many instances waste in working is reduced to a minimum, and although manifest improvement is being made in the working of coal, especially by the extension of the system of "long wall," nevertheless coal is wasted by bad working and by carelessness, and that to a very considerable amount in proportion to what is actually used. Under favourable systems of working the loss is about 10 per cent, while, in a very large number of instances, the ordinary waste and loss amounts to 40 per cent, irrespective of what is sacrificed by the necessity for leaving coal for barriers, for the support of buildings, and for other objects. This is a very considerable evil, and one which requires immediate attention. If it be necessary to husband our coal resources, means should be everywhere encouraged, not only for the introduction of an improved system of getting coal, so as to reduce the waste to a minimum, but for the better utilisation of small coal, none of which should be permitted to be left below that can possibly be raised. One method of utilising small coal, which is briefly referred to by Committee E, in their Report, is by the manufacture of patent fuel, but this is not at present carried on to a sufficient extent to have much effect upon the general question.

In considering the quantity of coal in known coal-fields, 4000 feet has been adopted as the limit of practicable depth in working, and a certain proportion has been allowed for waste and loss incident to working the coal. With these provisions, the estimated quantity of coal in the ascertained coal-fields of the United Kingdom is 90,207 millions of tons, whilst at depths below 4000 feet it is computed that there is a further supply amounting to 7320 millions of tons, which might be obtained if existing obstacles to working at a lower depth than 4000 feet were overcome. Space will not admit of our even touching on the considerations upon which the Commissioners express themselves in favour of finding coal under the permian and newer strata. The supply from this source, within the depth of 4000 feet, is roughly estimated at 56,273 millions of tons. It is also considered probable that coal measures may possibly extend beneath the south-eastern part of England; but Sir Roderick Murchison contends, in opposition to this theory, that "in consequence of the extension of Silurian and Cambrian rocks beneath the secondary strata of the South-east of England, and of the great amount of denudation which the carboniferous rocks had undergone over the area of the South of England previous to the deposition of the secondary formations, little coal could be expected to remain under the cretaceous rocks." As this question is still one of theory, no attempt has been made by the Commission to estimate the quantity of coal lying under the unexplored area of the South of England.

Omitting the probable amount of coal below 4000 feet in depth, there thus appears to be an aggregate quantity of 146,480 millions of tons which may be reasonably expected to be available for use; and it remains now only to see how long that quantity, with an increasing consumption, is likely to last. The bases upon which calculation may be made, as to the probable duration of our coal supplies, are numerous, and varying conclusions have been consequently arrived at by different authorities. The two great principles upon which such a calculation should be based are—the annual increase in population, coupled with the increase in consumption of coal per head of the population. Now, from the year 1811 to 1821 the increase in population was 16 per cent, while in the last decade, from 1861 to 1871, it was 11¾ per cent. These two rates of increase, in conjunction with those of the intervening decades, have been taken as the elements of a curve which, carried forward, shows the extent of the population in future years, supposing no disturbing causes to arise. The rate of consumption of coal per head of the population appears to have been very irregular; but, on an average, the increase in fourteen years amounts to nearly 3 per cent per annum, but it is not thought probable that this rate will be maintained. From statistical tables furnished by the Commissioners, it appears that the absolute increase of the consumption of coal between 1855 and 1859 averaged 0·035 ton per head per annum; that the next six years, 1859 to 1865, averaged 0·145 ton per head per annum; while the last four years, 1865 to 1869, only averaged 0·0463 ton per head per annum. From this it would appear that the annual increase has passed through a point of maximum increase, and that it is now diminishing.

Basing their calculation, however, upon an arithmetical instead of a geometrical increase in the rate of consumption, and simply adding a constant quantity equal to the average annual increase of the last fourteen years, taken at 3,000,000 tons, the Commissioners arrive at the following result, namely, that at the end of a hundred years the consumption would be 415,000,000 tons per annum, and that the now estimated quantity of coal available for use would represent a consumption of 276 years. Taking, however, another view of the case, and supposing that from this time the population of the whole country, and the consumption of coal per head of that population, will remain constant, or merely oscillate without advancing, our available coal would represent a consumption of upwards of 1273 years, at the rate of 115,000,000 per annum.

These two calculations, as to the probable duration of our coal resources, given by the Coal Commission in their Report, may probably be taken to represent two extreme cases, between which the actual truth may probably be found. Whilst, then, we may confidently anticipate the continued existence of coal for some 300 years at least, it by no means follows that its price will remain as at present. With increased depth of workings, and an increased difficulty in raising coal, its price must necessarily rise; and although, therefore, there is no fear that coal will become actually scarce in our time, the same effect will, in a great measure, be secured by its increase in price. The prevention of this evil can, apparently, only be effected by still greater economy in combustion, and the enforcement of a law that no coal, either large or small, shall ever be left in a working beyond what it may be impossible to gain.

V. THE SPECTROSCOPE: ITS IMPERFECTIONS AND THEIR REMEDY.

By Mungo Ponton, F.R.S.E.

THAT the spectroscope, as at present constructed, is an imperfect and fallacious instrument has been already indicated in a previous paper, entitled "Molecules, Ultimates, Atoms, and Waves." It is now proposed to show in what respect the instrument is objectionable, and how it may possibly be improved.

To understand the subject, it is needful to have some acquaintance with the laws of chromatic dispersion. An investigation into these laws will be found in the "Philosophical Magazine" for 1860, pp. 165, 263, 364. When those researches were undertaken, the only existing measurements of the wave-lengths corresponding to the principal fixed lines of the spectrum were those left by Fraünhofer. These wave-lengths, however, have been recently re-measured with more perfect appliances than Fraünhofer could obtain, by M. Angström, of Upsal, who has published the results in his work on the Normal Spectrum, accompanied by an illustrative atlas, in which all the most remarkable lines of the spectrum are laid down on an extended scale according to their wave-lengths.

Since that work was published, M. Angström's measurements have been analysed, and it has been ascertained that the whole of the wave-lengths corresponding to the principal fixed lines are capable of being calculated from one—namely, that corresponding to the more refrangible of the two lines marked E. The formulæ expressing the relations on which these calculations are based will be found in a memorandum contained in a work recently published.* It is there shown, moreover, that there is another curious relation connecting the whole of those wave-lengths together. While the other seven are all capable of being calculated from that of the more refrangible E, the sum of the three equations, by which are thus calculated the wave-lengths corresponding to the three lines A, B, and C, is equal to the sum of the four equations by which are calculated the wave-lengths corresponding to the four lines, D, F, G, and H. This remarkable relation seems to indicate that the wave-lengths of these lines are all interdependent, resembling the strings of a perfectly-tuned instrument, the key-note corresponding to the more refrangible E.

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* "The Beginning," &c. Longmans and Co. The memorandum is inserted between the notes and the description of the plates.

The extreme closeness of the agreement between the wave-lengths as given by M. Angström's observations, and those calculated by the formulæ, combines with this last-mentioned relation to show both the accuracy of the observations and the truth of the relations which the formulæ express. Great confidence may therefore be placed in the correctness of the wave-lengths as calculated from those formulæ.

It became interesting to inquire to what extent the laws of chromatic dispersion, as deduced from Fraünhofer's normals, might be affected by this alteration in the wave-lengths corresponding to the principal fixed lines. Investigation shows that those laws remain unshaken in their principles by this change in the elements of calculation.

The important practical use to which those laws may be applied is to check the accuracy of observations on the indices of refraction corresponding to the principal fixed lines in different media, for the observed indices rarely give results which tally quite exactly with the laws; but the alterations which they must undergo, to render the agreement perfect, are in general so small as to establish the laws, which may accordingly in their turn be employed to correct the indices.

The media, whose indices of refraction for the different fixed lines have been experimentally determined, fall under two categories,—1st, regular; 2nd, irregular. The former embraces by much the larger number of media; and as it is only with such that the spectroscope has any connection, it is to them that attention shall here be confined.

In all media whatever, the relation between the wave-length in the free ether and that within the refracted medium may be expressed by one and the same formula. If U represent the normal undulation, and u its reduced length within the medium, then is

$$\frac{U}{\varepsilon} - a \pm x = u,$$

where ε and a are two quantities constant for the medium and temperature, while x is a small quantity peculiar to each wave, and represents what is termed the irrationality of the medium, or, in other words, the extent to which the fixed lines are extruded or thrust out of their proper places. It is this quantity x, however, that is all-important in the correction of the observed indices of refraction; because it is regulated by peculiar laws, and the indices may be corrected by bringing them into conformity to those laws. If μ represent the refractive index in any medium corresponding to the undulation belonging to any fixed line, we have, of course, in every case,

$$\frac{U}{\mu}=\frac{U}{\varepsilon}-a\pm x=u.$$

But it is only where μ, the index of refraction, is quite correct that the quantities represented by x conform to their proper laws.

These quantities represent additions to or abstractions from the internal wave-lengths, that would arise from the more simple formula,

$$\frac{U}{\mu}=\frac{U}{\varepsilon}-a.$$

They constitute an evidence of a transfer of energy from one set of waves to another within the medium, and by its action. Now the general law of the conservation of energy requires that this transfer should involve an exact compensation,—that what is lost in length by one set of waves should be exactly the same as what is gained in length by another set, or, symbolically, the quantities represented by $+x$ must be exactly equal to those represented by $-x$. In every good set of observations on the indices there is a close approach to this equality, and this constitutes the first law regulating those quantities. It applies to all media, whether regular or irregular.

In all regular media the sign of x is plus for the three waves corresponding to the lines D, E, and F, and minus for the four waves corresponding to the lines B, C, G, and H. In the former the formula is always

$$\left(\frac{U}{\varepsilon}-a\right)+x=u=\frac{U}{\mu};$$

for the latter it is

$$\left(\frac{U}{\varepsilon}-a\right)-x=u=\frac{U}{\mu}.$$

If b_x, c_x, d_x, &c., represent the quantities x, corresponding to each internal wave, we have, in all regular media,

$$3b_x+2c_x-d_x=3h_x+2g_x-f_x.$$

If the difference between b_x and $h_x = \delta$, that between c_x and $g_x = \delta_2$, and that between d_x and $f_x = \delta_3$, then the differences between each pair of δ_1, δ_2, and δ_3, constitute an arithmetical progression.

In all regular media there are two nodes, at which the sign of x changes from plus to minus, the one situated between C and D, the other between F and G. Irregular media differ from regular in the position and number of these nodes, and in the arrangement of the quantities plus x and minus x; but the sums of each of these are always equal.

These laws, and the mode of their application to the correction of the observed indices of refraction, may be illustrated by a single example. For this purpose the specimen of flint glass marked No. 30 by Fraünhofer may be selected. The indices of refraction, as determined by him, are as under:—

B.	C.	D.	E.	F.	G.	H.
1·623570,	1·625477,	1·630585,	1·637356,	1·643466,	1·655406,	1·666072.

The normal wave-lengths corresponding to these seven lines, as observed by Angström, and corrected by the formulæ according to which they are calculated from E, are as follows, E being assumed as unity, and the others stated in reference to that standard:—

B.	C.	D.	E.	F.	G.	H.
1·3033839,	1·245493,	1·1189003,	1,	0·922576,	0·8175183,	0·7464871.

The lines D, E, and H, in the spectrum are double; but it is the less refrangible D, and the more refrangible E and H, whose wave-lengths are here given.

The internal wave-lengths in flint glass, No. 30, are found by dividing each of the above normal wave-lengths by its corresponding index of refraction. This gives the following values:—

b.	*c.*	*d.*	*e.*	*f.*	*g.*	*h.*
0·802789,	0·766232,	0·686196,	0·610741,	0·561360,	0·493848,	0·448052.

The constants, ε and a, for the formula

$$\frac{\mathrm{U}}{\varepsilon} - a \pm x = u,$$

are found thus:—

$$\varepsilon = \frac{(3\mathrm{B}+2\mathrm{C}+\mathrm{D})-(\mathrm{F}+2\mathrm{G}+3\mathrm{H})}{(3b+2c+d)-(f+2g+3h)},$$

and its value in this case is 1·570504. Then, calling the sum of the seven normal wave-lengths = S, and the sum of the seven corresponding internal wave-length = s, we have

$$a=\frac{(S\div\varepsilon)-s}{7},$$

and its value in this case is 0·026605. From the formula

$$\frac{U}{\varepsilon}-a=u_2$$

we obtain a second set of values of the internal waves, as follows:—

b_2.	c_2.	d_2.	e_2.	f_2.	g_2.	h_2.
0·803309,	0·766448,	0·685842,	0·610133,	0·560834,	0·493948	0·448712.

The differences between these and the former set are the quantities represented by x, and they stand as under:—

x plus.		x minus.	
d_x	0·000354	b_x	0·000520
e_x	0·000608	c_x	0·000216
f_x	0·000526	g_x	0·000100
		h_x	0·000660
Sum	0·001488	Sum	0·001496

The equality here, although near, is not perfect, showing that a slight adjustment is required to bring these quantities under the dominion of the general law of the conservation of energy, Neither do they perfectly agree with the other laws before mentioned, but the difference is small. When these quantities are adjusted according to the laws, neglecting the prefixed cyphers, they stand thus:—

x plus.		x minus.	
d_x	355	b_x	521
e_x	609	c_x	216
f_x	526	g_x	93
		h_x	660
	1490		1490

We have also—

x plus.		x minus.	
$3b_x$	1563	$3h_x$	1980
$2c_x$	432	$2g_x$	186
	1995		2166
Less d_x	355	Less f_x	526
	1640		1640

We have further the following arithmetical progression :—

$$\left.\begin{array}{rl} h_x-b_x=139 & \\ c_x-g_x=123 & \\ \cline{1-1} & 16 \\ f_x-d_x=171 & \\ h_x-b_x=139 & \\ \cline{1-1} & 32 \\ f_x-d_x=171 & \\ c_x-g_x=123 & \\ \cline{1-1} & 48 \end{array}\right\}\text{ Common difference 16,}$$

thus corresponding to the laws. By calculating backwards from these adjusted quantities we obtain the corrected indices of refraction, which will be found to differ but slightly from those derived from observation, as shown in the following table :—

	Observed.	Calculated.	Difference +	Difference −
B.	1·623570	1·623571	0·000001	
C.	1·625477	1·625477		
D.	1·630585	1·630582		0·000003
E.	1·637356	1·637350		0·000006
F.	1·643466	1·643463		0·000003
G.	1·655406	1·655398		0·000008
H.	1·666072	1·666061		0·000011

Also the value of ε becomes 1·570518, and of a 0·026598. These small differences are far within the limits of probable errors of observation.

Reverting to the normals, as wave-length is in the diffracted spectrum inversely equivalent to refrangibility, it follows that the positions assigned to the different lines in M. Angström's Atlas being fixed according to their wave-length, these must be their true positions in the normal spectrum, and that in so far as—in the spectrum produced by any set of prisms composing a spectroscope—the relative positions differ from those assigned to them in M. Angström's Atlas, such differences must be due to the action of the prisms.

To show to how great an extent the lines are displaced in M. Kirchhoff's spectrum, it is needful to compare the relative positions there assigned to the lines with those in M. Angström's Atlas. Fortunately this is not difficult ; for the interval between the more and less refrangible lines marked D, which in M. Angström's Atlas occupies six divisions, in M. Kirchhoff's occupies four ; and as the relative positions of those two lines cannot differ appreciably in the two spectra, each division of M. Kirchhoff's scale may be reckoned equivalent to a division and a half of M. Angström's. It is only necessary, therefore, to add a half more to each of Kirchhoff's intervals to make them equivalent to Angström's. The following table exhibits the intervals between the lines in the two spectra thus compared:—

	Angström's.	Kirchhoff's.	Differences +	Differences −
A—B.	737	285		452
B—C.	305	153		152
C—D.	667	463		204
D—E.	627	781	154	
E—F.	408	834	426	
F—G.	553	1162	609	
G—H.	374	1542	1168	
	3671	5220	2357	808

A simple inspection of this table suffices to show how much the lines are displaced from their true relative positions by the action of the prisms in M. Kirchhoff's spectroscope.

For the sake of further comparison, suppose a spectroscope to be constructed with prisms having the same refracting angles as those in M. Kirchhoff's instrument, namely, three with the angle 45°, and one with the angle 60°, but composed of flint glass, No. 30 of Fraünhofer. The following are the ultimate differences of deviation in seconds between the different lines, which would be given by such an instrument:

B—C.	C—D.	D—E.	E—F.	F—G.	G—H.	
1826,	4902,	6524,	5926,	11642,	10458.	Sum 41,278

For a short interval like that between the more and less refrangible of the two lines marked D, the differences of the indices of refraction may be assumed to bear to the differences of wave-length the same relation as they do in the case of the adjacent principal lines, which are here the less refrangible D and the more refrangible E. The difference between the relative wave-lengths of these two lines is 0·1189003, and the difference between the wave-lengths of the more and the less refrangible D is 0·0011378—the former difference being nearly 104·5 times that of the latter. The difference between the refractive indices of the less refrangible D and the more refrangible E for flint glass, No. 30, is 0·006768; and on the supposition that this difference is 104·5 times greater than that between the indices of the more and the less refrangible D, the latter difference will be

0·000065. This corresponds to a difference of deviation of about 62″ for the four prisms. As these 62″ of deviation correspond to six degrees of Angström's scale, if we take a tenth of the deviations we shall have the intervals for this flint glass according to M. Angström's scale, sufficiently near for the present purpose. The intervals between the lines resulting from these four flint glass prisms, as compared with those from M. Kirchhoff's four, and with the normals, will accordingly stand thus—

	Normals.	Flint Glass.	Kirchhoff's.	Diff. from Normals.	Diff. from Kirchhoff's.
B—C.	305	183	153	−122	+30
C—D.	667	490	463	−177	+37
D—E.	627	652	781	+ 25	−129
E—F.	408	593	834	+185	−241
F—G.	553	1164	1162	+611	+ 2
G—H.	374	1046	1542	+672	−496

It will be perceived from this table that the intervals of the spectrum, produced by the flint glass, No. 30, of Fraünhofer, approach more nearly in character to those of the normals than do those of M. Kirchhoff's, and that the increased dispersion of this last is in a great measure due to an excessive enlargement of the interval between G and H. The peculiar features of M. Kirchhoff's spectrum are probably traceable to his having given to his prisms curved faces, which, while increasing the dispersion, has augmented the irrationality in a still higher degree.

As all media tend to alter the intervals between the lines to a greater or smaller extent, it is evident that, if prisms are to be retained in the construction of the spectroscope, some device must be adopted in order to give those intervals their true value before the instrument can be regarded as satisfactory. The means that appear available for this purpose are the combining of different media, the giving of one or more of the faces of one or more of the prisms some peculiar curvature, or the introduction of both of those means of correction to render it more perfect. If, as in M. Kirchhoff's instrument, curvature of the faces of the prisms has so greatly increased the irrationality of the intervals, it seems probable that a similar device applied in a different way might be rendered available to restore them to their true values. The aim has hitherto been to obtain a very large spectrum by means of a great amount of dispersion, irrespective of the displacement of the lines; whereas the correct principle of construction should be to obtain an accurate spectrum, corresponding exactly with that obtained by diffraction, trusting to magnification by the telescope for increase of size.

In Mr. Grubb's spectroscope recourse has been had to a combination of flint and crown-glass in the construction of the prisms; there being a central prism of dense flint-glass and large angle, having cemented on each of its two refracting sides, in the reverse position, a crown-glass prism of one-fourth of the angle. Without knowing the exact refractive indices of the two kinds of glass employed for each of the fixed lines, it is impossible to do more than show approximately the effect of this combination on the intervals; but such an approximation may be made by assuming the indices. Suppose, then, that the flint-glass prism has the same indices as Fraünhofer's No. 30, and that the crown-glass has the same indices as Fraünhofer's No. 9, which, when corrected by the laws, are as under:—

B.	C.	D.	E.	F.	G.	H.
1·525832,	1·526849,	1·529587,	1·533000,	1·536052,	1·541659,	1·546566.

The differences between these and the observed indices are still more trifling than in the case of the flint-glass. Suppose the refracting angle of the flint-glass prism to be 90°, and that of each of the crown-glass prisms to be a fourth of this, or 22° 30′, the ultimate differences of deviation arising from such a compound prism would be in seconds as under:—

B—C.	C—D.	D—E.	E—F.	F—G.	G—H.
754,	1862,	2548,	2360,	4728,	4372.

The difference of deviation between the two lines marked D is 32″; consequently, if we take one-fifth of the above deviations, we shall have the intervals, according to M. Angström's scale, sufficiently near for the present purpose. They will then, in comparison with the normal intervals, stand as under:—

	Normals.	Comp. Prisms.	Diff. +	Diff. −
B—C.	305	151		154
C—D.	667	372		295
D—E.	627	510		117
E—F.	408	407		1
F—G.	553	946	393	
G—H.	374	874	500	

It is thus evident that, while the character of the irrationality is much altered by this combination, it is far from being removed. The almost perfect coincidence of the intervals E—F, in the above spectra, is remarkable.

It might nevertheless be possible, by the expenditure of a great amount of time and skill, to find a combination of prisms of diverse media, which, combined with a certain curvature of the faces of one or more of the prisms, might bring the intervals into a more or less perfect agreement with those of the normals.

The true and most effectual remedy, however, appears to be the having recourse at once to the diffracted spectrum in the construction of the spectroscope. There are, doubtless, great practical difficulties in the way of making a handy instrument on that principle; but it is believed that it will be found possible to surmount these more easily than to overcome those attending the obtaining of a refracted spectrum which shall exactly correspond with the diffracted. It is comparatively easy to produce a diffracted spectrum, by means of a system of equidistant fine lines viewed through a telescope at a distance of about 12 feet. The difficulty is to secure a good large spectrum, from such a system, within the compass of an easily portable instrument. Until that be accomplished, it would be well that every spectroscope formed with prisms should have its individual spectrum carefully compared with the normal spectrum formed by a standard instrument, and that a table should be constructed showing how much the positions of the principal fixed lines, and of the borders of the colours, differ in the refracted spectrum from what they are in the normal, such table to be attached to the instrument.

It may not be amiss, however, to throw out a few hints as to the practicability of constructing a compact spectroscope on the diffracting principle. Mr. Lewis Rutherford, of New York, has recently exhibited in London sets of equidistant lines ruled on glass, of which there are 1500 to the inch; and even with these fair diffracted spectra can be obtained. But it is better to have the lines very much closer than these. It is not difficult to obtain copper wire 1-200th of an inch in diameter. Suppose wire of this description to be so wound on a square frame as to leave between each strand an interval exactly equal to the diameter of the wire; this would give a hundred strands and a hundred equal intervals for each inch. A square frame, therefore, of 100 inches free space would contain 10,000 strands of wire, and the like number of equal intervals. It is believed that such a frame might be constructed without much difficulty, and, were it once constructed, any number of photographs might be taken from it, reducing its size to one quarter of an inch. The photograph would thus have 10,000 equidistant lines in the space of a quarter of an inch. These photographs might be taken on thin plates of quartz, cut parallel to the axis of the crystal, and the lines could be covered with a similar plate to prevent access of dust. By using quartz the extreme ultra violet lines could be obtained without absorption, and be rendered visible by means of a fluorescent screen. To prevent the effects of diffraction between the lines, in taking the photographs, the wire frame should have fine, thin, white paper placed behind it, through which the light should be admitted to pass through the frame, and all other light should be excluded from the camera.

Having thus procured the system of fine equidistant lines, the next point is to make such arrangements that a highly magnified spectrum could be obtained from them by means of a telescope placed at a moderate distance. Suppose a box to be formed about 18 inches in length, and that the system of fine lines, with its slit and collimator furnished with quartz lenses, are placed at the top of the box, about the centre, so that the spectrum formed may be thrown down to the centre of the interior of the box, an arrangement being provided for shifting the system of fine lines along a graduated scale, so as to bring successively the different parts of the spectrum into view. Suppose a very small plane reflector, of silver or speculum metal, to be placed in the centre of the interior of the box, at an angle of 45° towards the roof, to receive the image of the spectrum, and let the image formed by this mirror be in the focus of a parabolic reflector placed at one end of the box, so that the rays reflected from the small plane mirror shall be reflected parallel towards the opposite end of the box. Exactly opposite to this parabolic reflector let there be placed a reflecting telescope, the parabolic reflector of which shall receive the parallel rays, and concentrate them in its own focus on another small plane mirror, where they may be viewed by the eye-piece to be composed of quartz lenses. By this arrangement the light would never pass through any other medium than quartz, which does not absorb the ultra-violet rays. The rendering the rays parallel at once would obviate the necessity for viewing the spectrum from a distance, in order to obtain sufficient magnification, which might be secured of any desired amount, by means of the reflecting telescope, without much loss of light. For viewing the ultra-violet rays a fluorescent surface might be substituted for the first of the small plane mirrors.

The chief practical difficulty would be the procuring of two good parabolic reflectors for the instrument; but it is believed that these can now be made of accuracy sufficient for this purpose.

Great care would be required in taking the photograph of the fine equidistant lines, to secure their being accurately in focus; but the true focus once found and fixed, the photographs might be multiplied indefinitely, at a moderate cost.

These hints are merely thrown out for the consideration of practical opticians, and it is quite possible that there may be graver difficulties which have been overlooked. Nevertheless, the devising of some means for constructing a spectroscope on the diffracting principle is well worth the consideration of those engaged in the manufacture of this instrument; for until this principle be adopted, accuracy, certainty, and uniformity of results, cannot be attained.

VI. MODERN CANNON POWDER.

IN the year 1779, nearly a century ago, General Sir William (then Captain) Congreve was sent to Plymouth to examine the gunpowder with which the Fleet was then supplied, on which occasion he reported that there were only four barrels of serviceable powder in the whole of His Majesty's ships. This state of affairs was no doubt due to the fact that the country was then entirely dependent on private manufacturers for its supply of powder, and that the proof to which it was subjected was not such as to ensure its being of good quality. On discovery of the gross frauds which were thus being carried on with impunity, the Government Gunpowder Factory at Waltham Abbey was established, and, under the able superintendence of Sir W. Congreve, the quality of the powder supplied to the army and navy was greatly improved.

From this date until the general introduction of rifled guns in 1860, very little progress was made towards the development of this important manufacture, the only changes being in the direction of improvements in the preparation and purification of the ingredients, the quality of the finished powder being thereby improved, while its character remained unaltered. During the whole of this period the description of powder used with all cannon was what is technically called "L.G.," or "Large Grain," in contradistinction to "F.G.," or "Fine Grain," which was used with small arms and muskets; but this powder was believed to be too violent for use in the rifled breech-loading guns introduced about twelve years ago, and a modified kind was therefore adopted, on the recommendation of Sir William Armstrong. The modification consisted in making the powder much larger* in the grain, and in addition, coating it with a thin film of graphite, so as further to retard its combustion and thus to reduce the strain upon the breech-closing mechanism of the gun.

This new powder was at first called "A_4," but its name was afterwads changed to "R.L.G.," or "Rifle Large Grain" powder, when its use was extended to both muzzle-loading and breech-loading rifled guns. Now at the time of the introduction of this modified powder, the means of testing the action of the charge in the bore of a gun were very imperfect, and the change then made was founded almost entirely upon theoretical considerations. In order to understand these, and also the results of more modern experiments, it will be necessary to say a few words on the subject of the combustion of gunpowder.

In the first place it must be borne in mind that gunpowder, unlike nitro-glycerine, fulminate of mercury, and other detonating substances, is not a chemical compound, but only a mechanical mixture. By the incorporating process during manufacture the three substances of which powder is composed—saltpetre, sulphur, and charcoal—are so intimately mingled that the eye cannot detect the presence of any one of them in a free state. They are notwithstanding only mixed, and the saltpetre can be readily dissolved out by water, or the sulphur sublimed, in the form of vapour, by the application of a moderate heat, leaving in either case the other two ingredients chemically unchanged. The more intimate the mixture, the more nearly does gunpowder approach to a chemical compound, and the more violent is its combustion; but there always must remain a vast difference between the most complete mechanical mixture and the most unstable chemical compound.

For this reason the combustion of gunpowder is only very rapidly progressive, and not instantaneous as is the case with the violent explosives mentioned above. It is this difference that renders gunpowder so valuable as a propelling agent, for, were it not for its comparatively mild action, no gun could be made sufficiently strong to resist its force. The material of the cannon would be broken before the inertia of the shot could be overcome.

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* The size of grain in "L.G." powder is such that it will pass through a sieve of 8 meshes to the inch and be retained on one with 16 meshes, while the limits of "R.L.G." or "A_4" powder are between a 4-mesh and an 8-mesh sieve.

Now supposing one grain or particle alone to be ignited, it will be first inflamed over its whole surface, and the progressive combustion will take place from the exterior to the interior. Its *rate of combustion* will therefore depend upon both its shape and size, leaving out entirely for the present the question of density and hardness. A particle of spherical or cubical form will expose less surface to ignition, in proportion to its volume, than one of an elongated or flat shape, and will consequently require a longer period for the combustion of its entire mass: the larger the particle also, the longer will be the time required for its consumption. Looking, then, at one grain of powder by itself, we may safely say that the larger it is, and the more nearly does its form approach to that of a sphere, the longer will its combustion take, and the slower will be the evolution of the gas. When, however, we come to regard the action of an aggregation of such particles, as in the charge of a gun, the *rate of ignition* of the whole charge is also affected by the size and shape of the grains. The part of the charge first ignited is that near the vent, or touch-hole, and the remainder is inflamed by contact with the heated gas generated by the combustion of this portion, so that the rate of ignition of the whole mass will be regulated by the greater or less facility with which the gas can penetrate throughout the charge, which is itself dependent upon the size and shape of the interstices between the grains. If the grains be spherical and regular in form, the interstices will be comparatively large and uniform, and the gas will penetrate the mass with facility; again, the larger the grains, the larger the interstices between them. If, on the other hand, they be flat or flaky and irregular in shape, the passage of the gas will be more difficult, and the rate of inflammation of the charge reduced.

We see, therefore, that the considerations which affect the more or less rapid combustion of an individual grain of gunpowder also affect the rate of ignition of a charge of such grains, but in an opposite direction; so that a form of grain which will individually burn rapidly may offer an increased resistance to the passage of the heated gas through the charge, and thereby retard its ignition, while a grain which will burn more slowly may allow of the charge being more rapidly ignited. By varying the size and shape of the grain alone, a powder may therefore be obtained a charge of which shall be ignited rapidly throughout but burn comparatively slowly, or one which shall be ignited more slowly, but when once inflamed burn very rapidly. It is necessary to draw a clear distinction between a rapidly igniting and a quickly burning powder: this difference will be more apparent when we come to the discussion of more modern powders.

The grains in both L.G. and R.L.G. powder are very irregular in shape, and the latter is double the size of the former, so that the individual grains will burn more slowly. It was, therefore, believed on theoretical grounds that the larger powder would exert a less violent strain upon a gun, and it was adopted, as we have said, for our rifled guns, the question of *density* being regarded at that time as of minor importance, though it was already attracting some attention. It has since been conclusively proved by experiments that the *density* and *hardness* of the grains of powder are of quite as vital importance as their size and form, in determining the rate of ignition and combustion of a charge.

The density depends on the amount of pressure to which the powder meal has been subjected during manufacture, while the hardness is greatly affected by the amount of moisture present in the meal when pressed; one term applies to the mass, while the other refers more particularly to the surface of the grains. A dense powder may be generally stated to be a slow-burning powder, while a hard one is slow lighting. Density retards the combustion both because there is more matter in the same volume, and consequently more powder to be consumed in proportion to the ignited surface of the grain, and also because the heated gas finds greater difficulty in penetrating the solid mass of the grain. A hard powder need not of necessity be very dense; it is even possible, by pressing it in a moist state, to obtain a very hard powder which shall at the same time be light and porous in the interior of the grains. Such is the Russian prismatic powder (of which more hereafter), and it may be taken as a good specimen of a slow lighting but quick burning powder.

With the improved appliances now used in testing powder, the quality of the large stock of L.G. and R.L.G. in store in this country has been found to be very variable, principally due to variation in the density of different brands. Previous to the year 1868, the proof to which all cannon powders were subjected was very imperfect, and failed utterly in ensuring uniformity in those passed into the service. The density was only roughly ascertained by the process of "cubing," as it was called, while the strength and uniformity of the powder was tested by the "Mortar Eprouvette." "Cubing" consisted in weighing a cubic foot of the powder, a box made to hold that amount being filled by pouring the substance loosely into it; the weight therefore depended, to a great extent, upon the closeness with which the powder packed itself, as well as upon the absolute density of the grains. The shape of the grains, and the amount of glaze the powder has received, affect the closeness with which it packs itself, and would therefore lead to errors in determining the density in this way. At the present time the density is accurately arrived at, by means of a mercury densimeter, in which the weight of a given volume of powder is compared with that of an equal volume of mercury: the density of mercury (corrected according to the readings of a barometer and thermometer at the time) being known, that of the powder is easily calculated.

In the "Mortar Eprouvette" a round shot, weighing 68 lbs. was fired from an eight-inch mortar with a charge of from two to three ozs. of the powder under examination, and the range of the shot from the muzzle of the mortar was measured. The greater the range the better was the powder believed to be, the only limit being a low one. The fallacy of this belief was proved beyond a doubt as early as the year 1864, by comparing the velocity of shot fired with different powders, by means of the accurate instruments then generally in use for that purpose. It was then found that powers which gave the best results in very small charges fired from a mortar were often very inferior when fired in comparatively large charges from guns, and the immediate adoption of a new proof of powder, by measuring the velocity of shot fired under service conditions, was strongly recommended. This recommendation was not, however, carried out until four years later, when Colonel Younghusband, the present Superintendent of the Government Gunpowder Works at Waltham Abbey, introduced the velocity proof which is now in force. The instrument used at Waltham Abbey for measuring the velocity of a shot is an electro-ballistic chronoscope, invented by Captain Le Bouleugè, of the Belgian Artillery,* which surpasses all similar instruments in simplicity and facility of manipulation, though the principle upon which it acts is the same as in others. In it electricity is employed to record the exact instant at which the shot passes two points at a known distance apart, a short space in front of the gun. From this the time occupied by the shot in traversing the distance between these two points is known, and the velocity with which it is moving is readily ascertained, and affords a direct indication of the strength and uniformity of the powder. Every kind of powder now passed into the service is subjected to this proof, in addition to being tested by the mercury densimeter.

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* This instrument, and the method of using it, is described in detail in a pamphlet by Lieut. C. Jones, Royal Artillery, Instructor Royal Gun Factories. Printed by order of the Secretary of State for War.

We have stated that R.L.G. powder was adopted in 1860 for our breech-loading guns, and that its use was afterwards extended to the charges of all rifled guns. When, however, the size of our heavy ordnance was increased more and more, it soon became apparent that even this powder was totally unfit for the large charges then used, and its violent action earned for it abroad the unenviable *soubriquet* of "*poudre brutale*."

In the year 1858 the gunpowder question was referred to a Committee, composed of the Superintendent of the Royal Gunpowder Factory, the Superintendent of the Royal Laboratory, and the Chemist to the War Department;* and it was, in fact, some of the earlier experiments of this Committee that led to the introduction of A_4 or R.L.G. powder. The means at their disposal for determining the manner of combustion, and the pressure exerted upon the gun by different kinds of powder, were very limited. Nevertheless the conclusions they arrived at, as set forth in their Reports of 1859 and 1866, were very correct, and have been entirely corroborated by subsequent researches. As early as 1860 they had satisfactorily proved that the density and hardness of powder exercise an important influence on its character, and in all their subsequent experiments these points were strictly attended to. In their final report (1866) they recommended the adoption of a cylindrical "Pellet" powder of a density between 1·492 and 1·50, but pressed comparatively wet, so that, though light, the powder should be rather hard. The form of this powder is shown at Fig. 1, Plate I., the cavity or indentation having been introduced in order to increase the surface exposed to ignition. This powder was adopted entirely upon experiments carried on with various natures of Armstrong breech-loading guns and smooth-bored mortars, and it is evident that a light, but hard, powder, such as this is, which would be slow lighting but quick burning, would be exactly suited to breech-loading guns, in which the initial resistance of the tight-fitting, lead-coated projectile is very great, as the lead has to be bodily forced forward into the grooves of the rifling.

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* Colonel Askwith, R.A.; Captain Boxer, R.A.; and F. Abel, Esq., R.A., F.R.S.

The pellet form was recommended principally as a convenient method of making a large grain powder of considerable uniformity in size and density; but the Committee did not consider that the subject of gunpowder had been exhausted by them, and closed their Report with a recommendation that "systematic artillery experiments should be instituted with this pellet powder, of a sufficiently comprehensive character to test thoroughly the system."

In the meantime, while the labours of this Committee were still progressing, other experiments were being carried on in this country. In 1863-4 a proposal was made to press granulated powder into discs the size of the bore of the gun, and perforated with holes to facilitate the passage of the gas. These discs varied in thickness from 2 to 3 inches, and were made of powder of various-sized grains, the amount of the compressing force differing in different specimens. The results of these trials were not sufficiently satisfactory to lead to the adoption of this form of powder. About the same time a similar description of powder, proposed by Dr. Doremus, an American, was tried unsuccessfully, both in America and in this country; and again, in 1866, discs—made by compressing the powder meal—gave even less satisfactory results.

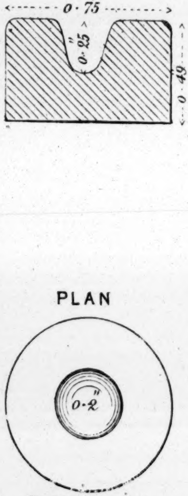
The Americans, about this period, introduced an irregular large grain powder, which they called "Mammoth," and still use in the large charges fired from their enormous cast-iron smooth-bored guns, to which they obstinately adhered for years after the remainder of the civilised world had been armed with rifled ordnance of wrought-iron or steel. The size of this powder ranges from 0·15 inch to 0·30 inch, and its density is very moderate, being 1·70 to 1·75.

"Prismatic" powder appears, also, to have been tried in America in 1865; it had already been fired with good results from the heavy steel breech-loading guns which the Russians and Prussians have obtained from Messrs. Krupp, of Essen. This powder is shown at Fig. 2, Plate I., being made in the form of regular hexagonal prisms about 1 inch thick and 0·8 inch in the side, perforated with seven holes about 0·1 inch in diameter. In making up charges of this powder, the prisms are built up regularly in the cartridge bags, like honey-comb, which are then tightly tied at the mouth, so that the grains are kept firmly in their place. The perforations thus form long tubes through the charge, by which the gas permeates the whole mass.

The powder meal is pressed into the shape of these prisms in a very moist state, but the pressure is not great, as the

Fig. 1

SECTION

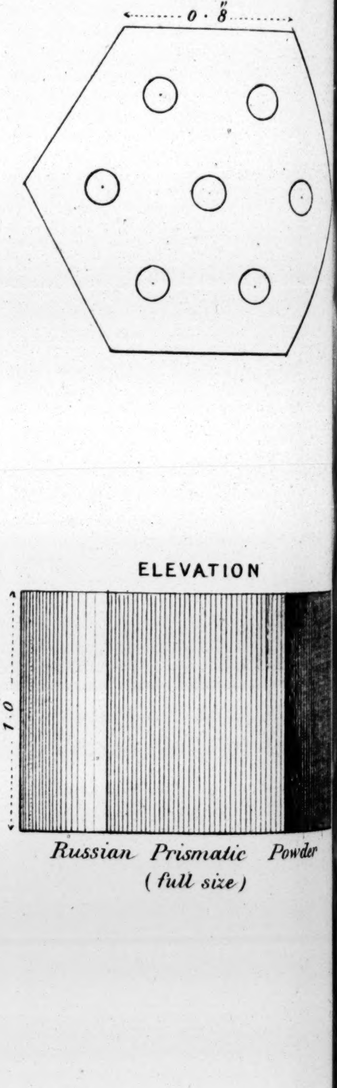


PLAN

Pellet Powder
(full size)

Fig. 2

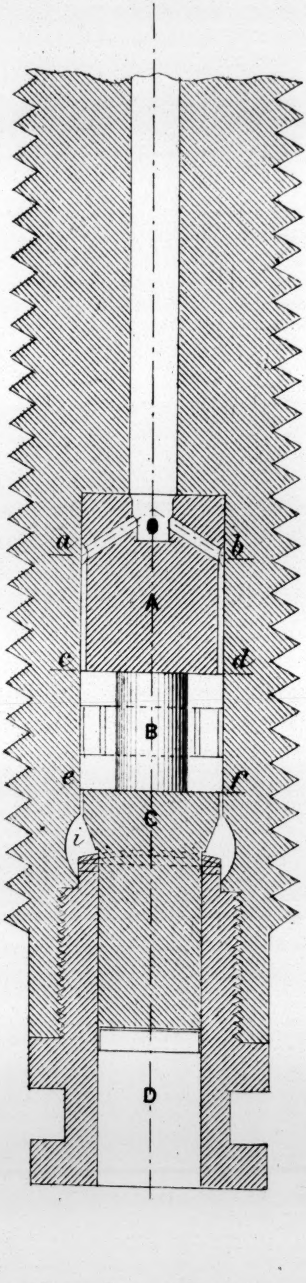
PLAN



ELEVATION

Russian Prismatic Powder
(full size)

Fig. 3.



Sectional Elevation
of
CRUSHING INSTRUMENT

Full Size

Vincent Brooks Day & Son

density of the finished powder is only 1·67. The surface is, however, very hard, and, being to a certain extent covered with a film of saltpetre, which is deposited by the moisture when the powder is dried, it is comparatively difficult to ignite; when once inflamed it burns very rapidly, being light and porous, and in this respect is very like the pellet powder recommended in 1866, being particularly suitable for breech-loading guns. Though this pellet powder was decidedly a step in the right direction, as the strain upon our guns was considerably reduced by its use, it was only nominally adopted into the service in 1867, and was never issued either to our ships or batteries. The reason for this was that there existed no machinery for manufacturing a sufficient supply, and, while the necessary machinery was in preparation, the results of the experiments of the present Committee on Explosives* led to its abandonment in favour of "Pebble" powder.

This Committee was appointed in May, 1869, to enquire generally into the value of various explosive substances,—such as gun-cotton, nitro-glycerine, &c.,—in use, or proposed, for military purposes, and more particularly into the powder question, in which, through mismanagement rather than ignorance, we had fallen behind the rest of Europe. They at once entered on an extended series of experiments, with a view to the "determination of the description of gunpowder whose employment in large charges is attended with the least risk of overstraining the heavy guns" we now employ, and have rendered two Preliminary Reports on this subject.† From these it appears that no less than forty descriptions of British and foreign powders have been fired in large charges from heavy guns, out of which number four varieties were selected for further experiments.

The guns used in these experiments are an 8-inch wrought-iron smooth bore of 6½ tons, and a 10-inch gun of 18 tons: the latter was first used as a smooth bore, and afterwards rifled.

The means employed by the Committee, in the investigation of the action of the large charges fired from these guns, are very ingenious, and may be briefly described as follows:—

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* This Committee consists of the following:—President—Colonel Younghusband, R.A., F.R.S. Members—Captain Singer, R.N.; Major Haig, R.A., F.R.S.; Captain V. D. Majendie, R.A.; Captain Stoney, R.A.; Captain A. Noble, late R.A., F.R.S.; F. Abel, Esq., F.R.S. Secretary—Captain W. H. Noble, R.A.

† Preliminary Report of the Committee on Explosive Substances; printed at the War Office, February, 1870; and Progress Report of the same, January, 1871.

1. The determination of the time taken by a projectile in traversing various intervals within the bore of the gun, which was effected by means of a chronoscope invented by Capt. A. Noble, a member of the Committee, and made at the Elswick Ordnance Company's Works. This will be described hereafter.

2. The determination of the pressure directly, by means of Rodman's pressure-gauge fitting on the exterior of the gun, and communicating with the interior of the bore by means of a hollow screw-plug.

3. The determination of the pressure directly, by means of an inner gauge termed a "crusher," which was designed by the Committee to overcome certain defects inherent in the Rodman gauge.

4. The determination of the velocity of the projectile after leaving the gun, by means of Navez-Leur's or Le Boulengé's electro-ballistic apparatus, commonly used for this purpose.

The chronoscope and the method of connecting it with the interior of the gun are shown in Plate II. The principle of action consists in registering, by means of electric currents, upon a recording surface travelling at a uniform and very high speed, the precise instant at which a shot passes certain defined points in the bore. The instrument may be divided into two portions; the one consisting of the mechanical arrangement for obtaining the necessary speed, and keeping that speed uniform; the other forming the electrical recording arrangement.

The first consists of a series of thin metal discs, A A, each 36 inches in circumference, fixed at intervals upon a horizontal shaft, S S, which is driven at a high speed by a heavy weight, B, arranged according to a plan originally proposed by Huyghens, through a train of gearing multiplying 625 times. The driving weight is continually wound up during the experiment by means of the handle H, and the requisite speed is obtained by accelerating the motion by the handle C. The precise rate at which the discs are moving is ascertained by the stop-clock, D, which can, at pleasure, be connected, or disconnected, with the revolving shaft, E, and the time of making any number of revolutions of this shaft can be recorded with accuracy to the 1-10th part of a second.

The speed attained is generally about 1000 inches per second linear velocity at the circumference of the revolving discs, so that each inch represents the 1-1000th part of a second, and, as the inch is subdivided by the vernier, V, into a thousand parts, a linear representation is thus obtained at the circumference of the discs of intervals of time as minute as the *one-millionth part of a second*. As a small variation in speed would affect the relations between the several records obtained, the uniformity of rotation is ascertained, on each occasion of experiment, by three observations,—one immediately before, one during, and one immediately after, the experiment, the mean of the three observations being taken as the average speed. The accuracy of the workmanship in the instrument is shown by the great degree of uniformity at which the speed is maintained. The Report gives the observations in six consecutive rounds; in two of these the speed was absolutely uniform, while the greatest variation in any round is as follows:—

1st observation, 625 revolutions made in 21·2 seconds.
2nd ,, ,, ,, 20·9 ,,
3rd ,, ,, ,, 20·7 ,,

The arrangement for obtaining the electrical records is as follows:—The edges of the discs are covered with a strip of white paper, and each is connected with one of the secondary wires, G, of an induction coil. The other secondary wire, H, carefully insulated, is brought to a discharger, I, opposite the edge of its corresponding disc, and is fixed so as to be just clear of the latter. The surface of the paper on the discs is coated with lamp-black, so that the passage of a spark from the discharger to the disc burns away the black, and marks the spot perforated by exposure of the white paper beneath.

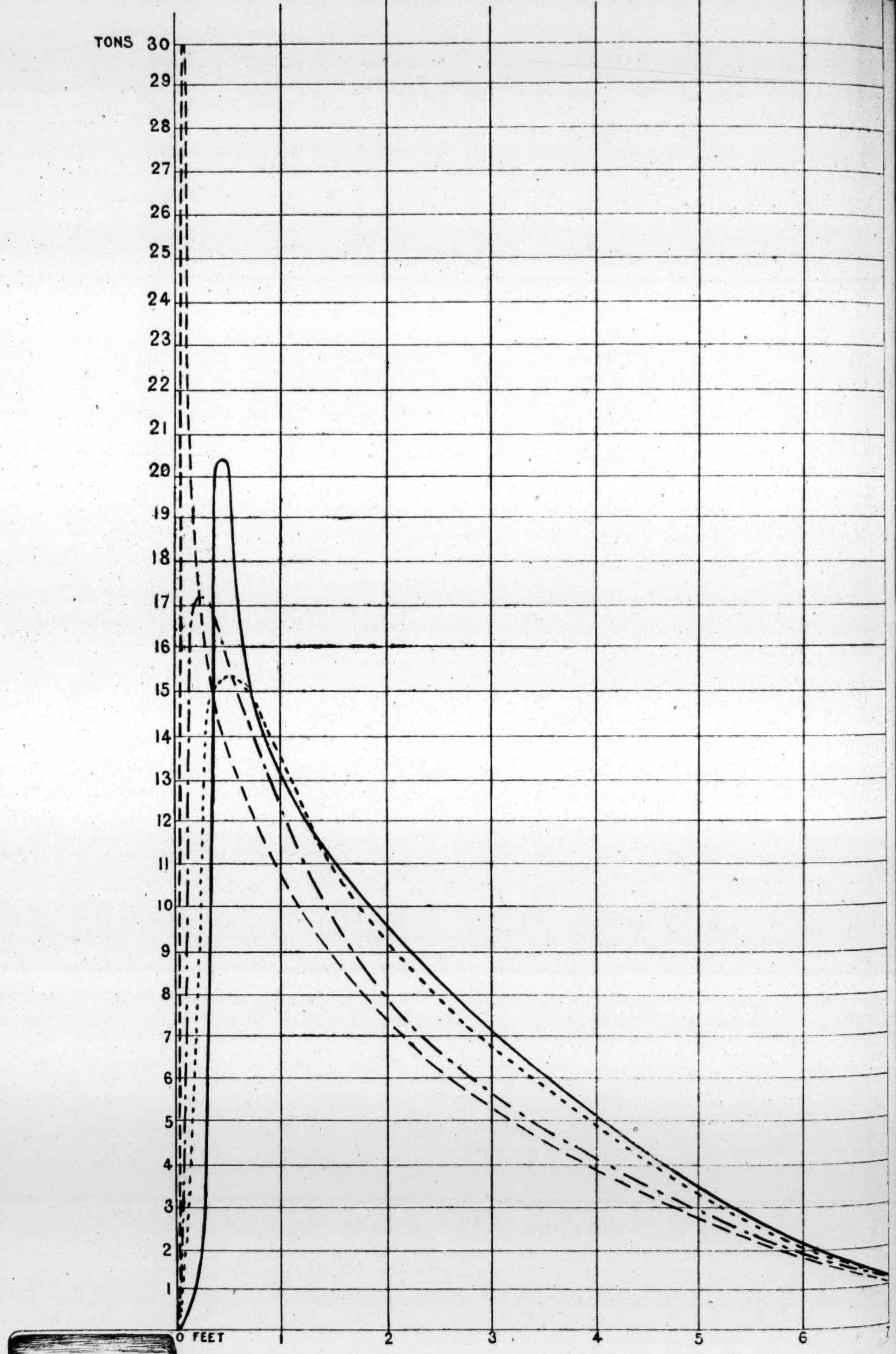
In order to connect the primary wires of the induction coils with the bore of the gun, so that they may be cut by the shot in its passage, the gun has been tapped in a number of places (see Plate II.) for the reception of hollow steel plugs, carrying at the end next the bore a cutter which projects slightly into the bore. This cutter is held in position by the primary wire, which is carefully insulated and passed down the plug, through the cutter, and back out of the plug, the ends being connected to the main wires leading to the induction coils. When the shot reaches the point where a plug is screwed in, it presses the cutter in flush with the bore, and, by so doing, cuts the primary circuit, thereby causing an induced spark to pass from one of the dischargers to the corresponding disc. As each plug is reached, a spark is delivered on the disc in connection with it, and thus the passage of the shot up the bore is recorded at regular intervals. By means of the micrometer, V, the distance between the sparks on the discs is read off, each spot being brought in succession exactly opposite the discharger belonging to the disc it is on: the speed at which the discs are moving being known, the time occupied by the shot in passing from one point to another is readily ascertained, and its velocity of translation calculated.

In order to test the accuracy of the instrument, it is only necessary to cut the whole of the primary wires simultaneously, when the whole of the sparks should be in one straight line, and the deviations from a straight line, that is, from an absolutely simultaneous record, give the instrumental errors.

Great difficulties were experienced in securing a simultaneous rupture of the primary wires, and only two methods were found at all satisfactory. One arrangement was to cut the wires by a flat-headed bullet fired from a rifle, across the muzzle of which they were all tightly stretched; in the other they were all wound round a detonating fuze, the explosion of which severed them almost instantaneously. A number of the observations thus obtained are given in the Report, and the errors—including those due to the impossibility of obtaining an absolutely instantaneous rupture of all the wires—seldom exceed 0·000003 second, while the maximum error is only 0·00002 second!

In addition to the holes tapped to receive the cutting-plugs already described, the gun is also bored to take a number of Rodman or "crusher" gauges. When any of these holes, which are twenty-one in number, were not required in the experiments, they were filled with solid steel plugs. The Rodman pressure gauge is shown in position in the gun (Plate II.): it consists of a piston, working in a hollow screw plug open to the bore, the outer end of which carries a pointed knife, against which a piece of copper is placed. When the gun is fired, the gaseous pressure on the base of the piston forces the knife into the copper, and the indent is a measure of the pressure which has acted on the base of the plug. In this instrument the gas has a considerable space to travel between the powder chamber and the piston; thus, before reaching the latter it attains a high *vis viva*, especially in quick burning powders, and acts upon the piston more like a blow than a pressure, and the records are therefore much higher than should be the case.

To remedy this defect the "crusher" gauge was devised by the Committee (see Fig. 3, Plate I.): the reduced dimensions of this instrument allow it to be placed so close to the bore of the gun that the gas has no space to travel before



Chronoscope Pressure Curves.

R.L.G. = – – – – – – – – – –

Prismatic = ————————

Pellet = -·—·—·—·—·—

Pebble = ··············

Horizontal Scale ½ Inch = 1 Foot
Vertical Scale ⅕ Inch = 1 Ton

Vincent Brooks Day & S

reaching the piston. It consists of a screw-plug of steel, having a movable base which admits of the insertion of a small copper cylinder, B. One end of this cylinder rests against an anvil, A, while the other is acted upon by a movable piston, C, which is kept tight against the cylinder by the spring, *i*. The cylinder is retained in the centre of the chamber, *c*, *d*, *e*, *f*, by a small watch-spring. A gas-check, D, is inserted against the lower extremity of the piston, and should any gas get past this there are passages by which it can escape into the open air. Upon the explosion of the charge the gas, acting on the area of the piston, crushes the copper against the anvil, and, the amount of pressure required to produce a definite amount of compression of the copper having been determined by previous experiments, the pressure on the piston is at once ascertained. The area of the copper cylinders used in the 8-inch gun was 1-12th of a square inch, and that of the piston 1-6th of a square inch.

We have stated that four varieties of powders were chosen out of a large number for further experiment: these were—R.L.G. service powder, pellet service powder, Russian prismatic powder, and "pebble" powder No. 5. When fired from the 8-inch gun, in charges which best suited each kind of powder, the following results were obtained:—

Nature of Powder.	Charge.	Muzzle Velocity.	Maximum Pressure.
	Lbs.	Feet.	Tons.
R.L.G.	30	1324	29·8
Russian prismatic .	32	1366	20·5
Service pellet . .	30	1338	17·4
Pebble No. 5 . .	35	1374	15·4

From this table it is evident that the Service R.L.G. is far inferior to all the others, while the pebble is manifestly the best.

"Pebble" powder, so called from its resemblance to small black pebbles, was first tried in Belgium, but the powder which gave the above satisfactory results is an improvement on the foreign powder, being more uniform in size and density. It consists of irregular cubes, having edges, from 5-8ths to 4-8ths inch in length, made by cutting up the "press-cake" into the required form; the powder is as usual glazed in a revolving barrel, which operation removes the sharp edges. Its manufacture is therefore very simple, little or no new machinery is required for its production, and it is cheaper than any of the other descriptions. Its density is high, about 1·8, but owing to its large size and comparatively uneven surface it is a quick-lighting powder: the whole charge (if of the proper form) is quickly and uniformly lighted, and the maximum pressure in the powder chamber is consequently even throughout its surface, while with powders which are both quick lighting and quick burning, like the old L.G. and R.L.G., intense local pressures, varying in different parts of the chamber, are produced. As an example of this the following results obtained in the 10-inch gun its smooth bore state are given.

			Pressure per square inch by Crusher Gauge at		
Powder and Charge.	Rounds.	Muzzle Velocity. Feet.	A. Axis of Bore. Tons.	B. Centre of Charge. Tons.	C. Front of Charge. Tons.
L.G. 60 lbs.	6	1273	49	28	29
Pellet 64 lbs.	3	1377	21½	21	21
Pebble 70 lbs.	6	1435	22	22	23

The explanation of these local pressures caused by quick burning powders is very clearly stated by Captain A. Noble, in a paper read at the Royal Institution, on the "Tension of Fired Gunpowder," and may be expressed briefly as follows:—The products of combustion of the first portion of the powder inflamed, in travelling from one end of the chamber to the other, attain a very high velocity before meeting with any resistance, and the re-conversion of the *vis viva* thus acquired into pressure at the base of the shot and the end of the bore, gives rise to the intense local pressures at those points, while the rapidity of combustion of the powder at that part of the charge is probably enormously accelerated by the tension under which it is exploded. "The time during which these abnormal pressures are kept up must be exceedingly minute, even when compared with the infinitesimal times we are considering; for we find the chronoscope pressure, which may be regarded as representing the mean of pressures of a violent oscillatory character, hardly altered at all, even although the local pressures are increased 50 per cent."

At Plate III. a representation is given of the pressure curves calculated from the chronoscope observations, and in the following table the pressures in tons shown by the crusher gauge are compared with those obtained by the chronoscope in the 10-inch gun.

			Pressure per square inch at															
			A.		B.		C.		Mean of B and C		1.		4.		10.		14.	
Charge.	Muzzle Velocity.	Total Work on Shot.	By Gauge.	By Chronoscope.	By Gauge.	By Chronoscope.	By Gauge.	By Chronoscope.	By Gauge.	By Chronoscope.	By Gauge.	By Chronoscope.	By Gauge.	By Chronoscope.	By Gauge.	By Chronoscope.	By Gauge.	By Chronoscope.
R. L. G. —60 lbs. D. 1·742	1327	4824	51·4	—	32·5	—	26·3	—	29·4	24·3	—	10·5	12·4	8·9	4·8	6·5	3·2	4·5
Pellet—64 lbs. D. 1·677 ..	1374	5164	25·0	—	22·9	—	20·1	—	21·5	22·2	—	10·4	11·2	9·0	5·2	6·3	—	4·3
Prismatic —61 lbs.	1344	4947	18·9	—	17·7	—	18·0	—	17·9	19·3	14·7	12·3	12·0	9·9	7·0	7·0	3·7	4·9
W.A. Pebble — 70 lbs. D. 1·782 ..	1442	5384	20·9	—	21·3	—	20·0	—	20·7	21·9	16·0	13·5	12·2	11·4	9·0	8·2	4·0	5·0

The letters and numbers refer to the plugs, reading from breech to muzzle as in the 8-inch gun Plate II., and it is evident that, with the mild kinds of powder the mean maximum pressure in the powder chamber, and also the pressure at different parts of the gun, arrived at by these two perfectly different methods of observation, agree very closely; while the intense local, or wave, action of the violent R.L.G. is also very apparent. The intensity of this local action depends, moreover, in a great measure upon the length of the cartridge; if this be excessive these objectionable strains at once begin to appear even in the case of pellet or pebble powder, as has been clearly demonstrated in the the 11·6-inch 35-ton gun, firing 120 and 130 pounds of powder, and also in the 10-inch gun when tried with proof-charges of 87·5 pounds.

The specification upon which pebble powder is received from the trade is very strict. Not only must the powder be very uniform in size and density of grain, but it is also further tested by firing battering charges (35 pounds) of every supply from an 8-inch gun, when the pressure in any part of the powder chamber must not exceed 20 tons on the square inch, and the variations in velocity must be comprised within narrow limits. By thus severely testing the whole of our supply of this new powder, the committee are able to ensure that it shall never depart in any important degree from the required standard. The admirable results obtained in the 8-inch and 10-inch guns with pebble powder have been maintained in all the heavier natures, insomuch that the use of this powder, while materially reducing the strain upon the guns below that caused by R.L.G., has at the same time augmented their power to a very considerable extent, as shown in the following table :—

Nature of Gun.	Charge, lbs.		Mean pressure per square inch in powder chamber.		Muzzle velocity.		Total energy of shot.	
	R.L.G. Lbs.	Pebble. Lbs.	R.L.G. Tons.	Pebble. Tons.	R.L.G. Feet.	Pebble. Feet.	R.L.G. Ft.-tons.	Pebble. Ft.-tons.
12 inch, 25 tons	67	85	23	19	1180	1300	5793	7030
10 ,, 18 ,,	60	70	32	23	1298	1364	4693	5160
9 ,, 12 ,,	43	50	21	15	1336	1420	3094	3496
8 ,, 9 ,,	30	35	30	20	1363	1413	2319	2492
7 ,, 6⅓ ,,	22	30	17	10	1430	1525	1631	1855

With this, the result of the experiments of the last fourteen years, we will leave the subject, though there are many other points of scientific and practical interest to artillerymen which have been set at rest by the committee's researches, while there are others which they are at the present moment investigating.

At one period, as we have already stated, this country was allowed to fall behind some foreign nations in the all important question of powder for heavy guns, and the capabilities of our magnificent Naval Ordnance were sacrificed, and their endurance endangered, by the use of a variable and violent powder. All this has now been set right, and it is satisfactory to feel that our ships and forts are not only armed with the best guns in existence, but that they are also being rapidly supplied with a powder in every respect suitable for their use.

NOTICES OF BOOKS.

Report on Spiritualism by the Committee of the London Dialectical Society; together with the Evidence, Oral and Written, and a Selection from the Correspondence. London: Longmans and Co.

The London Dialectical Society is an association professing perfect liberty of thought and speech. It was designed for the free discussion of every topic—social, political, and religious—and the hearing of all opinions and theories, however strange or heterodox, subjecting all equally to the ordeal of open debate, in confidence that the conflict of minds will promote the advancement of the truth, whatever that may be.

A creed so novel and strange as that of Spiritualism could not expect to escape the ordeal of examination by such a society. But too little was known of it to provide material for debate, and therefore a committee was appointed to inquire into the subject and to report upon it to the Society. The members of that committee were fairly selected, comprising a few votaries of the faith to be investigated, but an immense majority of positive unbelievers, and of those who knew nothing at all about it. But it comprised a great variety of minds and callings—men of science, literary men, lawyers, men of business—the whole being a jury of more than average qualifications to pronounce a fair verdict.

The committee resolved to divide their labours into two parts: the first business was to receive evidence of the experience of witnesses; the second duty was to examine and test the phenomena personally by the aid of their own senses and intelligence.

The General Committee took upon itself the work of examining the witnesses who might tender themselves for or against the new faith, and no difficulty was found in procuring them. Careful notes were taken of the examinations and cross-examinations, and the business was strictly limited to this. In addition, a great number of letters on both sides of the question from persons of distinction, scientific and social, were received, and these, with the reports of the *viva voce* examinations, occupy the greater portion of the volume.

We must say that in our judgment it was a mistake to have printed anything more than narratives of facts: the committee were appointed to inquire into phenomena, not to investigate causes. A considerable part of the Appendix is occupied with mere opinions, many of them ingenious, but some ridiculous and wild, which can interest nobody and are utterly worthless. In any future edition these should be omitted.

After all, the evidence is only the assertion of so many individuals that each had witnessed something which he describes, and carries with it only the weight of one voice. But the Investigation Sub-Committees are of vastly more importance, for they were appointed to witness the alleged phenomena, and to apply to them such tests as ingenuity might devise. Five-sixths of their members were entirely sceptical, and went to the work confident that they should discover a delusion or an imposture. They adopted every practical security against deception: they would not employ a professional medium, but looked for, and fortunately found, one in private life—a lady in high social position—who gave them her assistance through the entire of their protracted enquiry; and this lady had never seen any of the phenomena previously to its being accidentally discovered that they occurred in her presence.

Sub-Committee No. 1 was the most regular and persevering, holding altogether no less than forty meetings, of each one of which a careful note was taken, which is published in the Appendix to the volume before us. The Report states briefly and clearly the results of that careful examination.

Although five-sixths of the members were wholly sceptical when they commenced the inquiry, at its close all who had attended the meetings, so as to witness the phenomena and apply the tests, were completely satisfied that the phenomena were genuine—that it was not imposture nor delusion, as they had expected; and they state their conclusions to be:—

> "First: That under certain bodily or mental conditions of one or more of the persons present, a force is exhibited sufficient to set in motion heavy substances, without the employment of any muscular force, without contact or material connection of any kind between such substances and the body of any person present.
>
> "Second: That this force can cause sounds to proceed, distinctly audible to all present, from solid substances not in contact with, nor having any visible or material connection with, the body of any person present, and which sounds are proved to proceed from such substances by the vibrations which are distinctly felt when they are touched.
>
> "Third: That this force is frequently directed by intelligence."

It will thus be seen that the Committee of the Dialectical Society, comprising a large body of sceptics, after cautious examination by a different class of experiments from those detailed in this journal, arrived at the same conclusion as Mr. Crookes,—that there is a psychic force that operates upon inanimate matter beyond the bounds of actual muscular contact or connection; that this force is associated with some special organisation in certain persons; and that it is often directed by some intelligence. But to the conclusions of the sub-committee, the objection was taken that possibly their senses were deceived —that they were themselves in the condition to which the absurd and *non*-scientific name of Electro-Biology has been given, and that they saw and heard only what the medium willed them to see and hear. Improbable as was this explanation, it was not absolutely impossible, and it was to test it beyond doubt that Mr. Crookes devised the mechanism described in former numbers of this journal. Wood and metal at least were not capable of being biologised, whatever that may mean; these materials were not subject to the influence of fear or wonder, but could record only the impression actually and physically made upon them. The reader already knows the result of the experiments made with these passionless agents; they are on all-fours with the results obtained by the forty experimental meetings of the Investigation Sub-Committee. Two or three of the tests employed by the Committee are worth recording, to show the care and ingenuity with which those tests were applied.

So long as there was actual contact with the table, even by a single finger, there was no absolute certainty that muscular force was not the motive power. The attention of the Committee was therefore directed to obtaining, if possible, motion without contact. In this they were entirely successful—not once only, but so frequently as to place the phenomenon beyond doubt. The experiment was contrived thus:—The backs of the chairs were turned to the table, and the party knelt upon the seats, thus precluding possibility of contact with the feet. The arms were laid on the backs of the chairs with the hands extended over the table, in full light, so that the slightest motion of any person would be visible to all the others. The hands were thus held at first at a distance of 6 inches from the table—a heavy and large dining table. It moved several times over a space of from 4 to 7 inches. The hands were withdrawn successively to distances of 9, 12, 18, and 24 inches from the table: still it moved as before, and the sounds came from it. Then the party stood round it at a distance of 3 feet from it, holding hands, and in this position the table moved over a space of 2 feet at one lurch, and frequently over lesser spaces. This did not occur on one evening only, but the experiment was repeated again and again with the same results. It must be observed that the psychic was not a paid or professional medium, but one found in private life whose uprightness was beyond question.

The Committee of the Society limited their investigation to the testing the reality of the phenomena. It was no part of their duty to inquire into the causes, and therefore being completely satisfied, although entirely sceptical when they commenced their labours, they contented themselves with reporting the results, and the minutes of each meeting as they were verified by the signatures of those present are published in the Appendix.

This, however, forms the smallest, though the most important and valuable portion, of the Report. It contains also the evidence taken *viva voce* of the experiences of a great number of distinguished as well as undistinguished persons, who describe a vast variety of phenomena very different from those which the calm and vigilant eyes of the sub-committee were enabled to view. Without questioning the veracity of any of those witnesses, it is sufficient to say that some portion of the marvels they narrate are explicable by certain well-known principles of mental action, whereby ideas formed *in* the mind are by the mind projected as it were outside itself, and appear to itself as if they were impressions conveyed by the senses, when, in fact, they are existing only in the sensorium. It may fairly be anticipated that the scientific examination with which this Force will be subjected everywhere, now that its existence is established, will solve also many of the problems in which the more obscure phenomena of Psychology are at present involved, and we shall obtain a clear insight into the causes of some things which now are inexplicable. At all events, the plain duty of Science is to submit to the most careful and elaborate examination and test all those physical phenomena of Psychic Force that are capable of scientific examination.

Following the *viva voce* evidence are letters received by the committee from a great number of persons eminent in science, literature, and art, who state frankly their opinions—some accepting, others denying, the truth of the phenomena. But it is worthy of remark that all who are convinced have become so after personal examination of these phenomena; while all who deny them, without a single exception, have either never seen them at all or have not bestowed upon them the same patient trial as they would have given to experiments in chemistry or magnetism; and it is a striking fact that there is not a solitary case of any person after a patient investigation coming forward to declare that he had discovered an imposture, and to show by what contrivance the trick was done so that it might be imitated by others.

The Editing Committee have been, we have said, *too* impartial in the introduction of opinions, for they have occupied many pages with mere speculations, such as those of Miss Blackwell, which were certainly not within the proper scope of an inquiry that was designed to collect facts, not opinions. Should a second edition be called for, and we hear that the sale has already become very large, we would recommend to the committee to omit all this portion of the work, and so to reduce its bulk and price. It will thus be introduced to a very wide circle of readers, who now can procure it only from the book club or the circulating library, but who would prefer to possess it for reference as well as for reading. It has made a great stir in the world, and must produce results still more important, for this Report is the testimony of a skilful and intelligent body of men to the reality of phenomena which have been neglected only because they have been erroneously assumed to be delusions or impostures. Now that they are proved to be neither, but facts in Nature, they will be seriously examined by thousands, and by that examination truths of the utmost importance to physiological science cannot fail to be elicited.

The Antiseptic System: a Treatise on Carbolic Acid and its Compounds; with Inquiries into the Germ Theories of Fermentation, Putrefaction, and Infection; the Theory and Practice of Disinfection; and the Practical Applications of Antiseptics, especially in Medicine and Surgery. By ARTHUR ERNEST SANSOM, M.D. Lond., M.R.C.P., &c. London: Henry Gillman. 1871.

DR. SANSOM has succeeded in avoiding any display of that enthusiasm generally attached to the investigation of a single agent; the failures as well as the successes in the application of carbolic acid meet with due recognition. Considering the theories of fermentation, putrefaction, and infection that have been promulgated, Dr. Sansom, after much deliberate independent investigation, concludes that the germ theory, notwithstanding its formidable opponents, still holds its ground, if, indeed, it may not be considered to have taken an established position. He leans to the opinion that the active agents in inducing the changes in fermenting masses are vegetable, not animal, structures. The mobile bacteria and vibriones observed in the early stages of organic decomposition are considered to be non-essential to the processes of decomposition, while the fungoid elements play an essential part. In putrefaction the material affords a more fitting pabulum for forms of animal life, and the complications due to the appearance, vital acts, and mutual decompositions of animalculæ, are superadded to make the process still more complex. But merely theorising is not Dr. Sansom's aim; he places in a light clear to all the numerous practical applications of carbolic acid in the destruction of noxious fungi and insects, and in preventing putrefaction; the action of carbolic acid on inoculable virus; on the poisons of infecting diseases, &c. The action of carbolic acid in surgical cases is treated in the most interesting manner, the details of each case being stated, while the *pros* and *contras* are carefully reasoned out. Dr. Sansom says of the action of carbolic acid on putrefactive decomposition that, "Abundant experimentation has proved that carbolic acid prevents the putrefaction of organic substances. A piece of meat soaked in a 1 per cent solution of carbolic acid for one hour entirely resists putrefaction. Gut, skin, &c., in like manner resist decomposition. Animal size and glue in solution mixed with small quantities of carbolic acid are perfectly preserved in hot weather. Albumen precipitated by carbolic acid does not putrefy. A perfectly fresh egg placed in a sealed bottle, whose interior is coated with a thin lining of carbolic acid, may be preserved perfectly fresh for two months, although the bottle contain plenty of air; nearly the whole of the albuminous material is unchanged by the carbolic acid. Meat treated in like manner may be preserved untainted. A sparrow preserved by Lemaire presented at the end of a month no signs of decomposition, its features being as firmly implanted as just after death. Putrefactive decomposition has also been prevented in the cases of fœcal matters and of blood. As well as preventing decomposition in cases in which the process has not yet commenced, it has also been proved that carbolic acid can arrest putrefaction when once it has set in. Thus meat was hung in the air till the odour of putrefaction was strong. It was divided in two pieces; one was soaked in a 1 per cent solution of carbolic acid; the other in a solution of chloride of lime. In a few weeks that soaked in chloride of lime solution was very offensive, whilst the other presented no bad odour. When vessels were lined with carbolic acid, if by chance air were introduced so that volatilisation of the agent could take place, putrefaction commenced; when, however, the substance experimented upon was soaked in carbolic solution no putrefaction took place." Thus it will be seen that the work is essentially practical, what the agent *might* effect having been left out of the question. The medical applications and the toxic action of carbolic acid, not within our province, are similarly treated. Carbolic acid as a disinfectant receives full attention, the deduction from experimental evidence being that carbolic acid is inferior to metallic salts as an antiseptic when water is freely present; but that when it is a question of the *immediate* disinfection of the semi-solid excreta, then a strong solution of carbolic acid, or emulsion of oil of tar, is highly valuable, or a carbolic powder may be employed. We cannot do more than recommend our readers to peruse Dr. Sansom's work, not merely for its special interest, but as conveying clear knowledge of the nature, the action, and of what is required of antiseptics.

Address delivered at the Spring Meeting of the Royal Institution of Cornwall, on the 23rd of May, 1871. By WILLIAM JORY HENWOOD, F.R.S., F.G.S., &c., President of the Institution. Truro: Netherton. 1871.

THIS address is one which might serve as an example to future presidents of many institutions and associations; each page shows an extensive reading and deep research into the matter in hand—chiefly the mineralogy of Cornwall. Mr. Henwood very clearly explains the technical and local terms in use among the miners, and gives a description of the principal geological characteristics of the lodes and elvans. But the most striking feature of the address is the list of works consulted and referred to. The address concludes with an interesting history of the several steam-engines and their boilers employed in pumping water from the mines.

Organic Philosophy. Vol. III. Outlines of Biology.—Body, Soul, Mind, and Spirit. By Hugh Doherty, M.D. London: Trübner and Co. 1871. 556 pp.

Works on speculative philosophy cannot be noticed in a few words, because there is no standard sufficiently recognised to which they can be at once adjudged. Further, links in the chain of reasoning that may seem accurately forged to some, to others may appear as bearing an undue tension. This is the case in this instance. The views of Aristotle and Anaxagoras, which have been current with many schoolmen, seem to Dr. Doherty unsatisfactory, and their division of the subject illogical. Yet all these views may to a certain extent be correct. As far as they deal with things tangible we can say whether they are correct or incorrect; but the moment the imagination is called into play the standard is removed, and the judgment falls back upon individual reasoning. Then the chances of error that present themselves are innumerable, for of the actual working of the mind we know comparatively nothing; the functions of our intellectual nature may in their complexity possess a paradoxical simplicity, but as yet they are practically entirely unresolved. With this saving clause we can proceed to the consideration of Dr. Doherty's analysis of vital unity. "The Body," he says "is a complete physiological aspect of synthetic unity; the Soul is a complete psychological aspect of synthetic unity; the Spirit is a complete pneumatological aspect of synthetic unity; the Mind is a complete noological aspect of synthetic unity." Hence, according to these definitions, we have the physical functions of the body, the spiritual functions of the spirit, the instinctual functions of the soul, and the mental functions of the mind, as the entire functions of vital unity. How nearly the last three divisions are correct is, as has been said, a matter for individual reasoning. Granted that the subject is correctly so divided, Dr. Doherty certainly follows a logical course of reasoning, and his collateral remarks show a most extensive reading, not only in the branch of philosophy of which he treats, but also in the exact sciences.

The book is well worthy mature deliberation. It is the third of a series of five volumes. The first volume is an outline of Episcosmology (the three kingdoms of nature on our globe, *epicosmos*); the second is a general view of Ontology (eternal forces, laws, and principles); the fourth will be an outline of Systematic

Sociology; the fifth a treatise on Dialegmatics, or Biological Methods, in parallel with mathematics, as a science of method. In treating of Spiritual Genealogy under the principal division of Spiritual Biology, the author speculates—"Palæontology testifies that inferior types of animal organisms have preceded superior types in their first appearance on earth, and therefore the latter must either have started into life at once, without progenitors, or come into this world by the procreative co-operation of inferior types. We suppose the latter to be not impossible, although no instance of such a fact has been recorded in history during the last 6000 years; and natural selection with hereditary transmission mark such very small degrees of variation within known limits that we cannot give it credit for the real origin of species. The possible incarnation of superior types by nearly related inferior progenitors is, then, a rational mode of accounting for the terrestrial origin and metamorphic evolution of individuals and species. Pre-existence may account for both the rise and fall of mankind on earth, as well as for the appearance, development, decline, and final disappearance of any collective realm or species of animal or vegetable organism, and thus ultramundane origin is not less important than mundane genealogy in problems of spiritual evolution. If uncultured and indocile races of spirits were incarnated on a large scale during many generations in the families of a highly cultivated and morally refined nation, such a process would eventually bring the nation down to barbarism and ruin. New revelations and religions may disorganise old nationalities, and re-construct them on new foundations of laws and doctrines, as history shows in all past ages; and in either case ultramundane causes, in the shape of extraneous incarnations or spiritual revelations, produce the mundane effects of social and religious evolutions and revolutions. These are problems of collective biology which we shall have to deal with again, when questions of sociogenesis will suggest those of realmogenesis, still more puzzling and complex; for although we may account for the spiritual conservation and progressive evolution of extinct races of mankind by successive incarnations in superior races living on the earth, we cannot easily conceive the transformation of *lost palæontological* types of animal organism and instinct by successive incarnations, since this would not be heterogenetic evolution in outward form alone, but also in organic constitution; a problem of ultramundane as well as of mundane evolution. The Darwinian theory would account for all kinds of creation by mundane variations transmitted to posterity, but that ignores all worlds of life beyond the natural and the lymbic, and pre-supposes the destruction of souls as well as bodies at the death of individuals. . . . . Incarnation means the descent of immortal spirit into a mortal body by the process of embryogenesis. Resurrection means the rising of immortal spirit from the mortal body. This is not the vulgar notion of the resurrection of the mortal body as a mass of dust which had long been scattered to the winds." Such reasoning is beyond the scope of, and cannot be criticised in, a mere notice. The full consideration would absorb many pages of this journal, and in the end would but express the reviewer's opinion.

Miscellanies. By JOHN ADDINGTON SYMONDS, M.D., Selected and Edited, with an Introductory Memoir, by his Son. London: Macmillan and Co. 1871.

BESIDES a memoir these miscellanies comprise articles on general subjects, scientific studies, papers on the social and political aspects of medicine, as well as poems and translations from classical authors, all from the pen of the late Dr. Symonds. Dr. Symonds was one of those men who derive their energy from a strong desire of cultivating the beautiful, and who, working quietly and intensely during their lives, leave their biographer to astonish the reading world with the versatility of their achievements. The chief essay is that on the Principles of Beauty, following up Mr. Hay's idea that the harmony of forms can be explained by the proportion of the component angles; that is, a form is beautiful when the space which it encloses can be analysed into angles which bear proportions to each other analogous to those which subsist between the notes of music. The elaborate manner in which Dr. Symonds has worked out this subject is characteristic of the remaining essays. The translations in verse from the Greek Anthology everywhere present the delicate appreciation of a scholar and of a refined mind. This book should certainly be set on the shelves devoted to the lighter literature of science.

Animal Plagues: their History, Nature, and Prevention. By GEORGE FLEMING, F.R.G.S., President of the Central Veterinary Medical Society, &c.; Author of "Horse-Shoes and Horse-Shoeing," &c. London: Chapman and Hall. 1871.

THIS essentially is a chronological history of animal plagues from B.C. 1490 to A.D. 1800. Mr. Fleming endeavours to show the baneful effects of the maladies, particularly those of a contagious or spreading character, on the agriculture of the country, and how much has been lost by neglecting to study these maladies —a study, says Mr. Fleming, in which the comparative pathologist, physician, general historian, agriculturist, or statesman will find much material for reflection. The author presents a volume bearing on every page evidence of the most patient research. Latin, French, and German accounts of murrains that have from time to time appeared are cited chapter and verse, giving the reader the advantage of making fuller reference for himself should it be required. The arrangement is good: given disease or date, the rest is soon found. But besides the history of each plague there are many valuable conclusions drawn by Mr. Fleming as to the probable cause or causes of the pest. Apart from its special value, the book is very interesting as a general history.

Description of an Electric Telegraph. By Sir FRANCIS RONALDS, F.R.S. Second Edition. London: Williams and Norgate. 1871.

THIS is a reprint of a work published in 1823 when telegraphy was in its extreme infancy. Sir Francis Ronalds describes a telegraph now considered as ranking amongst the historical curiosities of the employment of electricity as a means of communication between distant places, being, in fact, an application of a static charge to cause the diversion of a pith-ball electrometer. The interest of the little work is consequently purely historical; but we cannot wonder that the author should seek to claim attention to his share in the introduction of that connecting link between nations—our present system of telegraphy. The method of testing for faults in the insulation of his line is, in its completeness, quite worthy of the present system.

Insects at Home.—Being a Popular Account of British Insects, their Structure, Habits, and Transformations. By the Rev. J. G. WOOD, M.A., F.L.S., &c.; Author of "Homes Without Hands," "Common Objects of the Sea-Shore and Country," &c. 700 Illustrations. London: Longmans and Co. 1872.

MR. WOOD is so well known by his former works that anything new from his pen will be certain to find favour; but even were he unknown as an author the work now presented to the public would be sufficiently meritorious to establish his fame. "Insects at Home" is a most comprehensive account of the infancy, maturity, and we may say social life of English insects. Moreover, it is an introduction to the study of entomology; and here the beginner will derive great advantage from the clear definition of the many hard names peculiar to this branch of natural science. The task of identifying an insect is by no means an easy one when, as in many entomological works, a very fair knowledge of Greek is required to render the terminology intelligible; but by clear definition and a system of reference by numbers, the author has effectually surmounted this difficulty. The plan of illustration is novel. As the colouring of the woodcuts throughout the work would have greatly increased the cost, the figures are but slightly shaded, and in many cases only outlined. This admits of the reader colouring the woodcuts according to the description given in the text, affording him by these means an illustrated entomological encyclopædia of great fulness at a low price. The filling-in of the colours by the reader has a further effect—it impresses upon his mind the distinctive features of representative class insects. The mounting, modes of preparation and preservation, and all matters relating to the cabinet, are likely to prove extremely useful to the student and to the curator.

Elementary Treatise on Physics, Experimental and Applied. Translated and Edited from Ganot's "Elements de Physique." By E. Atkinson, Ph.D., F.C.S., Professor of Experimental Science, Staff College, Sandhurst. Fifth Edition. London: Longmans and Co. 1872.

Another edition of Dr. Atkinson's work has been called for, and he has availed himself of the opportunity by adding many new illustrations, and much new matter selected from those subjects calculated to take a permanent place in elementary instruction. A larger type has been adopted in this edition, rendering the work still more easy of reference. All that need be said is, that this has been long the standard text-book of physical science.

A Manual of Anthropology or Science of Man, based on Modern Research. By Charles Bray, Author of "The Philosophy of Necessity," "Force and its Mental Correlates," &c. London: Longmans and Co. 1871.

Mr. Bray is sufficiently known as the author of some very pertinent works on psychology to render unnecessary any reference to his peculiarly pointed style—he may, indeed, be termed a common-sense writer. This, when the apparent difficulty of taking a common-sense view of the subject is considered, is certainly more than a mere compliment. The book endeavours to show the Unity of Force, and that all Power is Will Power, conscious or automatic, or, as Mr. W. R. Grove has put it, "Causation is the Will, Creation the act of God."

"Physics and Metaphysics, Physiology and Psychology," says Mr. Bray, " thus become united, and the study of man passes from the uncertain light of mere opinion to the region of Science." The habit of quotation, for which perhaps this author is remarkable, here stands him in good stead, and while it gives weight to his reasoning, prevents that straining after the unknowable, so common with writers on that difficult threefold question of the Whence, Why, and Whither. We are glad to see that Mr. Bray has touched upon the phenomena of will or soul force—in fact, a necessary part of his theory. He says:—"The sun has an atmosphere, the world has an atmosphere, and so has man. . . We all know how we are drawn to some people and repelled by others when we are brought within their sphere. But the character of the emanations around us has never been very definitely determined even where its existence has been admitted. Of its existence, however, there can be no doubt, although it is not recognised by physiologists or medical men except in some cases of disease. . . . . Vital force is so strong in others that they possess a curative power by its transmission in cases where healthy vital force is deficient. Old people imbibe vital force when sleeping with young ones, and all persons deficient in vital force draw largely from those with whom they sleep, causing or greatly increasing rheumatic and other pains. In the transmission of force from brain tissue we not only transmit mental states, but these other forces come more or less under the dominion of the Will, accounting for much in electro-biology, mesmerism, and so-called spiritual phenomena. But these are abnormal states; in the natural state the 'released heat taking its character from the tissue,' (Dr. Bird's theory) mixed with more material emanations, forms our personal atmosphere, and people are much more under its influence than they are disposed to credit. Our thoughts and feelings are greatly influenced by those with whom we come in contact, and especially by those with whom we habitually associate, the influence depending upon the particular brain tissue from which the force emanates. . . . . The extent to which we give and take depends upon the constitution. Highly nervous people are very sensitive to the impressions about them. Medwin, writing of Shelley, says: 'So sensitive was he of external impressions, so magnetic, that I have seen him, after threading the crowd in Lung' Arno Corsos, throw himself half fainting into a chair, overpowered by the atmosphere of evil passions, as he used to say, in that sensual and unintellectual crowd.' These phenomena are now illustrated on a very large scale in what are called spiritualist circles. All that is wanted is observation and experiment; but we must look in the right direction for *spirit*, not *spirits*, and for nervous and bodily forces and emanations." Mr. Bray continues, "Professor Owen, writing about what he calls 'thought-force,' says, 'if lines of thought-force were visible, the ghost (of Samuel) would not therefore be more material.' May, then, thought-force, ever become visible? It is evident Professor Owen does not think it impossible. Does what is called by spiritualists 'a medium' supply the conditions?"

Mr. Bray's work should certainly be read. His creed seems to be—know the knowable, *et permitte cætera Deo.*

Rudimentary Treatise on Geology. Part II.—Historical Geology. By RALPH TATE, Assoc. Lin. Soc., F.G.S, Corr. Mem. Acad. Sciences Philad., &c. London: Lockwood and Co. 1871.

THIS little work, partly based on Major-Gen. Portlock's Rudiments of Geology, is one of the admirable Weale's series. This second volume forms a complete epitome of the "History of the British Stratified Rocks." All the principal varieties of fossils are illustrated. The reputation of Mr. Tate as a geologist is a sufficient recommendation that the work will be found accurate in detail.

The Great Pyramid of Gizeh. By A. F. D. WACKERBARTH, F.R.A.S., Professor of Mathematics in the University of Upsala. Translated from the "Tidskrift für Matematik och Fysik." Southampton: Gutch and Cox. 1871.

THE Great Pyramid constitutes a subject which is now being investigated by an increasing number of researchers, and from numerous points of view. The literature of the subject is rapidly growing, and it therefore becomes us, when—as it has already been said in our pages—"theories of such momentous importance are in the balance," not to pass over unnoticed any contribution thereto which may be fairly expected to tend further in the direction of unveiling the still deeper hidden interpretations of realities, which have remained shut up unheeded in perdurable granite and limestone from pre-Abrahamitic ages, down to these latter days, when the light primevally enclosed in thickest masonry of truest form in line and angle seems ready to illumine whole horizons of high antiquity, which have become overlain with multiplied wrappings of misty scales concreted in succeeding darker ages.

Under the principle of founding our acceptance or rejection of theories whenever and by whomsoever propounded, only when they accord or disagree with hard facts, we have examined the latest contribution to the literature of the Great Pyramid, whereof the title appears in the heading of this article. Much pleased, indeed, should we have been if that we could add the work had withstood the test; glad should we have been to sound abroad that its conclusions are founded on a basis as stable as that of the material Pyramid itself; yet in a sentence it must be said, that as the root is planted in fiction, it foreshadows for itself as certain, and like unto that of all half-done work, a precarious and at most but an ephemeral life.

Yet such an assertion on our part is valueless without evidence of being rightly founded. We will, then, endeavour in a few succeeding pages to show forth the true character of the work which has caused us to conclude as aforesaid.

The very opening sentence of the work declares that "the number of Egyptian Pyramids amounts to *several hundreds*," and that the largest and oldest amongst them is the Great Pyramid of Gizeh. How utterly contrary to fact the former part of this assertion is may be gathered by reference to page 189 of the preceding volume of this journal, and to the writings of Howard Vyse, who explored the Pyramids more extensively than anyone else in modern times. We quote his words:*—"The Pyramids of Middle and Lower Egypt are *thirty-nine* in number. They are situated on the western side of the river, and chiefly on the desert hills which form the western boundary of the valley of the Nile."

1	was in the Nome,	Latopolitis.
33	" "	Memphitis.
2	" "	Heracleopolitis.
3	" "	Crocodilopolitis.
Total 39		

In order to make up even this small total number there are included many which were originally small and unimportant, and now become mere rounded rubbish heaps of decay-stricken bricks or unwrought stone. Had there been so many as the aforesaid "hundreds," they must necessarily have become a long-maintained Egyptian institution, and it would have occupied the Egyptians all through their history to build them. But quite contrary to that, it is abundantly proven that the idea of a Pyramid was introduced to the land at once perfect, full, and completely developed; it was to some extent, never entirely, never in anyone of its essential characteristics, imitated by a few succeeding generations, in perpetually descending dimensions and order of construction, until finally, and that long before the zenith of ancient Egypt, when both kings and subjects had wealth and power enough to erect any and every kind of building for themselves, Pyramid building had altogether ceased among them. Hence the Pyramids of Egypt occupied but a short period only of the early history of that people, just as they stretch over but a small portion of the earlier settled part of the country—namely, from the apex of the Delta to about fifty miles south thereof.

It is stated in the work before us, that in the lowest chamber of the Pyramid there "is a well formerly supplied with water from the Nile." The fact, however, is that this hole is not a well, but merely a shaft sunk by Howard Vyse and Perring, in 1837, in their search after a lower chamber; and as the bottom of this shaft does not reach down to the level of the highest Nile inundations of the present day, when they are hypsometrically 10 feet above their ancient rise, it is perfectly clear, that whereas the subterranean chamber is near 40 feet higher still, the waters of the Nile could never have reached it by natural flow or infiltration. In the same breath is another mystification, thus—"the chambers are all destitute of hieroglyphs." With somewhat of astonishment would the years'-stricken author of "The Monumental History of Egypt" hear this! And what would the shades of Howard Vyse declare could they address us? And Richard Lepsius too, with the very first plate in his world-famous "Denkmaeler," exhibiting some of the very hieroglyphs themselves as they were found by Vyse, painted in red minium, in some of the "chambers of construction?" Strangely significant is it that in the sectional drawing of the Pyramid forming part of this Swedish work, the essential *five* "chambers of construction" above the "King's Chamber" are omitted. Among the most important testimonies which the entire building contains are these particular hieroglyphs, and notably among them the cartouche of Shufu; they not only confirm the date of the building and name of the king by whom, Herodotus tells us, the Great Pyramid was built, but more than that, they show that the date made out on astronomical grounds is true also. The hieroglyphic, historic, and astronomical dates all closely agree to something near about the year B.C. 2170.

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* Pyramids of Gizeh, by Colonel HOWARD VYSE, vol. iii. p. 1.

Proceeding onwards we are assured that "this singular theory (*i.e.*, the modern metrological and esoteric theory), was first broached by a *Medical* (*sic*) Professor of Oxford, Dr. Greaves." In his "Pyramidographia," however, published in 1647, the same John Greaves announces himself as "Savilian Professor of Astronomy at Oxford," and this is confirmed, too, by the learned Dr. Hooker: whilst as if to destroy altogether at one blow the labour of modern researchers, it is asserted that "this" (Professor Greaves's) "view has been lately revived by the Astronomer-Royal for Scotland, Professor Piazzi Smyth," which, however, as being so excessively wide of the fact, any candid reader may be satisfied of by a careful examination of the last-named Professor's "Life and Work at the Great Pyramid," wherein doctrines exactly opposite to those of Greaves's are advanced.

As concerning the size of the monument, at page 5 of the dissertation, is to be found a host of erroneous statements, far too numerous to receive attention individually within the limits of a mere review, as to what the Scottish Astronomer-Royal has propounded. We may instance the following:—"He is obliged to make a number of arbitrary assumptions, among which we signalise his assumption 'that the ancient Hebrew standard of length or *sacred* cubit was exactly 25·025 English inches, equal to our 10-millionth part of the earth's polar semi-axis.'" M. Wackerbarth seems lamentably ignorant, if in strict sincerity he so writes. Has he acquainted himself with the directions left to his successors by no less a philosopher than Newton, who some 150 years ago wrote how the true measures of the ancient cubits, both *sacred* and *profane*, would eventually be found by better admeasurements of the stones of the Pyramid? Has he studied the several indications which the stones give, indeed, of two widely distinct cubits having been employed? One, by numerous indications giving a value slightly on the + side of 25 inches, or so close to 25·025 inches, that that particular length is marked out by no less than five different representations! The other by as many, indicating 20·7 as the length of the common or profane cubit; whilst both are doubtless identified in many more representations now gradually being unfolded! M. Wackerbarth, too, may be surprised to learn, that whilst indications of the linear value of these two cubits have been hitherto found scattered at different parts throughout the structure, very lately they are discovered to be laid up together in a specially-set-apart portion of the ante-chamber, with their subdivisions as plainly marked as in an ordinary 2-foot rule; nevertheless the two cubits are so strikingly placed there, that whilst both visible to simultaneous contrast, they are still separated as the *sacred* and *profane* ever must be, even so that they cannot touch each other.

On the same page as that from which the preceding passage is quoted we find it stated, that "Professor Smyth, moreover, assumes, in the teeth of all that is historically known about the Pyramid, that, though built before the age of Abraham, it is not an Egyptian but a Hebrew building," which is simply not true; as anyone may be assured of by turning to "Life and Work," vol. iii., Div. 3, chaps. 2 and 5, on the Egyptian Quarry Marks and Egyptian History of the Times of the Great Pyramid.

Further on it is stated that Professor Smyth, instead of using the mean of the base-length quantities ascertained by him, assisted by Messrs. Aiton and Inglis (which quantities, be it remembered, were from the very nature of the circumstances under which they had been ascertained, at best but uncertain approximations), adopts a length of 9142 inches, and in another place 9166 inches, because to bring out two different results which the theory involves, these two values are called into requisition; all of which in mild expression—is a most un-unjustifiable misrepresentation of what the said Professor has set out. It would be well that those who have not seen sufficient as yet to accept the modern theory of the Pyramid, should remember that the several individuals who have worked at its evolution have not attempted to assert anything except in cases where the chain of evidence leads up unbroken to a definite index, where doubts exist, as they certainly do, in regard to the length of the originally perfect base side, the probabilities of certain eventual results have been discussed, and no one has more openly confessed that than Professor Smyth, by publishing to the full *all* the observations of the only accurately marked base-side features, viz., the "socket corners," which he has been able to collect; and finding them to differ from 9102 to 9168 inches, has admitted the difficulty of drawing at present any final conclusion. Professor Smyth has furthermore pointed out on what grounds he at the time of writing deduced 9142 inches as the more probable length, but with an uncertainty about it of ± 25 inches nearly. And who will come forward to *show* (not merely *assert*) that Professor Smyth was not acting aright, in not putting implicit trust in the mean value evolved from the joint measures made by himself with Aiton and Inglis, especially when those made by the Royal Engineers in 1869 gave 9130 inches, or a value immensely closer to his deduced quantity of 9142 than 9110 is. When, however, M. Wackerbarth takes the mean between the Royal Engineer's measure of 9130 inches and the aforesaid 9110, or 9120 inches as being the real length of the base-side, and totally ignores the more carefully measured quantities of the French Academicians—Colonel Howard Vyse and Perring—respectively 9163 and 9168 inches, he himself, on his own showing, tampers with the published measures to confirm a theoretical result of Sir Henry James's long since exploded; according to which it was sought to prove that the base contained 500 Greek cubits of 18·2415 inches—a cubit, indeed, that was never heard of by any ancient Egyptian, nor known in Egypt, until 1500 years after the Pyramid was built; declared, too, in total disregard of what Herodotus told his Greek audience, viz., that the Egyptian cubit was the same as the Samian, Asiatic, or Persian cubit, which so far from being anywhere near the assumed quantity of 18·2415 inches, was 20·7 inches nearly; and this corresponds completely with what Sir Gardner Wilkinson and other modern Egyptologists have ascertained. More than remarkable, too, is it, after what our author has previously said, that he should even be found to testify to the same important truth. For in his table of Egyptian measures (page 15), evidently reprinted from an abstract of a former paper, published in the "Proceedings of the Royal Society of Edinburgh" (vol. vi., p. 235), he distinctly sets forth the cubit of 20·699 inches as a grand culminating quantity. The immediately preceding measure being an alleged equivalent of the Greek Σπιθαμη' = 9·61925 inches, the supposed cubit of 18·2415 inches not being even acknowledged as a possibly distinct standard quantity. It is almost useless to add that such a position is too glaring to need comment.

In paragraph 2, page 6, M. Wackerbarth alleges, that whereas Professor Smyth had only rough stone steps to measure from, he nevertheless "by taking means, and then again means of means, of different measurements of the angles of the remaining stones," made his measurements being out for the side angle of the Pyramid, 51° 51′ 14·3″ = hypothetical π angle. We require to answer such an assertion by merely stating that anyone who will take the trouble to refer to "Life and Work" (vol. ii., pp. 165—176;

vol. iii., p. 28), will find that Professor Smyth never attempted any such unscientific or blundering procedure; but from several sources (all of which gave values of the angle of rise due to the true π angle), found that the residual features of the building afforded evidence of that particular angle in preference to any other. On this same page also it is stated, that "Sir Henry James has completely solved the mystery of the Pyramid's gradient angle, by the simple observation that the corner lines rise 9 units in height for every 10 units of horizontal distance along the angles." It is true, indeed, that in the pages of a contemporary Sir Henry James did try to make out such a case, but it does not appear to have been known in Sweden that that particular attempt had not been recognised as successful in this country.[‡]

With regard to what indications the Pyramid has been shown to afford concerning the mean value of the solar radius-vector—most notably, too, just at the time when astronomers are divided into two mighty opposing armies on the point, waiting to settle their differences on the occasions of the coming transits of Venus,—M. Wackerbarth seems unaware that that particular feature was evolved by W. Petrie, although he ascribes it to Professor Smyth, and omits to notice how the discussions of Powalky in 1864, and Professor Simon Newcomb in 1867, point out W. Petrie's Pyramid quantity; and that it falls right in the middle of all the values declared by no less than thirteen of the foremost modern astronomers.[*]

Touching the coffer, a statement purporting to be a description of this vessel is given on page 7, full to overflowing with misstatements and omissions of facts published by various observers, and not by any means free from abuse of the vessel itself for any scientific purpose, by reason of what M. Wackerbarth supposes to be monstrous irregularities of figure. These irregularites are, however, so proportionately small, that they had escaped the notice of all observers prior to Professor Smyth; and although it is sounded in high tones, re-echoed from these observations alone, that no one of the surfaces is "plane," and attempts are made to show them in error by an amount really hideous to an accurate mind, yet the unalterable facts remain. And they assert that the errors in the plane of the east side of the coffer are in height absolutely invisible, and in length over a run of 91 inches, under 0·02 of an inch, or almost certainly within the probable error of the measuring scale, and not the slightest notice is taken of what later observers have shown as qualities—nay, commensurabilities due to the particular irregularities of figure in question. Nor is it even hinted at that certain others—and notably Captain Baker, R.E.,—attach first-rate importance to the concavity of three sides, and the flatness of the fourth, or eastern one.

Pages 8, 9, and 10 contain misrepresentations far too numerous to mention and refute. The following may therefore serve as an example of the whole. Professor Smyth's measurements of the entrance passage, and the accuracy of the angle thereof, are sought to be invalidated by the large differences among the observations of other travellers. But if the account of observations made by the Scottish Astronomer-Royal be searched, it will be found that these were at least ten times more numerous than any of his predecessors, and made with far more powerful instruments too. Next, the astronomical explanation of the angle of the entrance passage begun thirty-five years ago, by Sir John Herschel, and completed by Smyth, is most unfairly set forth, and treated as of no moment, because shorn—*first*, of the patent fact of the entrance passage being *in the plane of the astronomical meridian*, even more correctly than many modern observatories; *second*, of the consilient meridian data of both the Pleiades-stars and the Vernal Equinox, with the polar star of the passage α Draconis.

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[*] See Proc. Phil. Soc., Glasgow, vol. vii.

[‡] See "Papers on the Pyramid," by ST. JOHN V. DAY. 1870.

With regard to this last star an attempt is made to show that in the star map, "Life and Work," vol. iii., it is marked as of the second magnitude; whilst in Ptolemy's time, it seems to have been of the third magnitude; and that Sir John Herschel says it is now only of the fourth magnitude. Yet what are the facts? In Sir John Herschel's letter[*] to Howard Vyse, he connects the star not with the fourth but with the third magnitude; and Smyth, in the particular star-map alluded to, has not entered Draconis as of the second, as M. Wackerbarth states, but of the fourth magnitude.

We must, however, conclude our unhappy duty of pointing out the exact value of this most condensed example of misstatement which it has thus far fallen to our lot to examine. We might, indeed, carry our examination much further, but that is needless; and we close this paper with the feeling that if the supporters of the modern theory of the Pyramid have only such opposition to contend with, it may be matter of congratulation to them that their "enemy did write a book."

The Micrographic Dictionary: a Guide to the Examination and Investigation of the Structure and Nature of Microscopic Objects. By J. W. Griffith, M.D., &c., the late Arthur Henfrey, F.R.S., F.L.S., &c. Third Edition. Edited by J. W. Griffith, M.D., &c.; assisted by the Rev. M. J. Berkeley, M.A., F.L.S., and T. Rupert Jones, F.G.S, &c. Parts I. to III. London: J. Van Voorst.

The rapid progress of Microscopical Science since the publication of the last edition of this well-known book of reference in 1860, has rendered the work of revision and addition absolutely necessary. This has been ably accomplished so far as can be judged by the small portion at present issued. The introduction, treating on the construction of the microscope, its accessory apparatus, and the methods of investigation employed, has been corrected as closely as possible to the date of publication. The assistance of Messrs. Berkeley and Rupert Jones augurs well for the treatment of such very interesting microscopical subjects as Cryptogamic Botany, the *Foraminiferæ*, and Micro-Geology. The text has been added to wherever needed, and the bibliographical notes extended; further additions, however, might have been made in this department with advantage, as one of the student's greatest difficulties is to find references to books. The plates have been corrected; some, however, which have been re-engraved after those in the former editions by Tuffen West have lost, as might be expected, somewhat of their original delicacy; and the microscopist who is familiar with the style of this accomplished artist will miss the work of an old friend whose place can be to him but ill supplied.

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[*] See Vyse's Pyramids of Gizeh, vol. ii., p. 170 (foot-note).

The book, saving in this respect, is in no way inferior to the preceding issues, and still forms a most valuable addition to the library of the working microscopist. Considering the great increase in the number of those who now make use of the microscope, principally owing to the formation of societies in and around London and in the country, it seems a question whether the work might not have been profitably issued at a somewhat lower price than formerly; for, although the cost is spread over a large period by the issue in parts, yet the work is still an expensive one, and beyond the means of many earnest students who might be induced to purchase it if obtainable by the expenditure of a smaller sum.

A Systematic Handbook of Volumetric Analysis; or, The Quantitative Estimation of Chemical Substances by Measure, applied to Liquids, Solids, and Gases. By FRANCIS SUTTON, F.C.S., Norwich. Second Edition. London: Churchill. 1871.

EVERY chemist will welcome the second edition of Mr. Sutton's handbook. So much has been done in chemical science since the first edition was published seven years ago, that the revision of even a standard work has been necessary. Volumetric analysis presents nothing very new, but there are many modifications and improvements in the processes. This system of analysis requires, perhaps, a more extended experimental knowledge of the reaction of bodies upon each other than is required in gravimetric analysis; but given this knowledge, there is an immense saving of time and labour. Dr. Frankland and Mr. W. Thorpe, F.C.S., have contributed largely on the analysis of water to this second edition; and Mr. Herbert M'Leod, F.C.S., Professor of Chemistry and Experimental Science at the Indian

Civil Engineering College, furnishes much information on the analysis of gases. The work is too well-known as a technical handbook to need any recommendation. Mr. Sutton must, however, be thanked for keeping pace with the progress of science.

Life Theories: their Influence upon Religious Thought. By LIONEL S. BEALE, M.B., F.R.S., F.R.C.P., &c. London: J. and A. Churchill. 1871.

THE physical theory of life, despite its many advocates and its present vigorous propagation, seems destined to decline at no distant period. It has to meet an almost insuperable difficulty at its outset; for it appeals directly against all the religious prejudices of mankind, while it holds in view no sufficient recompense—except to those enthusiasts and zealots whose recompense is to be known as its propagators. Moreover, its fundamental proposition is founded on assertion, for although influential philosophers have stated that the non-living passes by insensible gradations into the living, no matter in the state of transition has ever been brought to light. This is the point taken up, and ably so, by Dr. Beale in his examination of the present theories of life. He shows how the present hypotheses of spontaneous generation are supported by only the vaguest conjectures, pointing out the true opposition of the living and non-living, of formative agency and formed matter, and that formative agency is not mere force, but force conquered and regulated. Who would say that force was competent to construct a wheel or build a mill? and yet there are men who hold that the sun's force constructs a worm or a plant. Vitality is not the slave of force, but has ever proved its master. Then, says Dr. Beale:—

"If the phenomena of living beings cannot be fully accounted for by physics and chemistry, it is a question still open for discussion whether or not life is due to the working of some agency or power distinct from matter, and the idea of a much higher power capable of influencing all matter may not only be entertained without inconsistency, but an additional argument is gained in its support."

"*Of Power and Force.*—I beg the reader to consider the vast difference between power, force, and property, for these are quite distinct from one another. Power is capable of activity; it may design, arrange, form, construct, build. Property is passive, and belongs to the material particles, and is no more capable of destruction than the particles themselves. Force differs from property in that its form or mode may be changed or conditioned and assume other forms, and be afterwards restored to the original one. Power may cease and vanish, but property is retained, and force in one form or other is persistent."

If vitality be at all acknowedged it must logically and essentially follow that living matter of all kinds and at all periods differs altogether from non-living matter.

"The transcendant difference is not due to chemical composition or to physical constitution or property, but to the presence and activity of a power which cannot under any circumstances be developed from matter that has not been made to live by the influence of that which is already living."

We have, then, in all living beings two distinct sets of phenomena—*vital* and *physico-chemical;* and while the physical properties always remain, the vital may disappear, never to reappear. But can the living exist independently of the non-living? Here we touch upon one of the most difficult and strained questions of the day—a question which has received considerable examination in the immediately preceding numbers of this journal.

"It must be acknowledged that we are not able to adduce scientific evidence in proof that the *living* can exist independently of the *non-living*, because the only evidence obtainable by us is obtained from and through the material. Such a conception, however, may present itself to the mind, and it seems not unreasonable to believe that *vitality* may after all belong to an order of *activities* or *immaterial agents* of which we can really learn nothing directly by the assistance of our senses. Nevertheless, from the effects of the supposed agency upon matter, we can conceive of it as an actual existing power; and by studying accurately the results of its working, why should we not succeed in drawing a correct conclusion concerning its nature and the mode of its action upon matter?"

"After having studied the phenomena of living matter for a length of time and with all the advantages I could obtain, the conviction has been forced upon my mind that vital phenomena must be referred to the influence of an agency distinct from the physical forces of nature. The hypothesis I have been led to adopt is this. I suppose that there is operating upon every particle of every kind of living matter, a *forming, guiding, directing power* or *agency*, which is constantly at work, being transmitted from atom to atom."

"Do not the words 'physiology,' 'biology,' 'pathology,' 'health,' and 'disease,' imply processes that are not simply physical,—imply, in fact, a psychical factor? In spite of all that has been urged to the contrary, there is not one of the actions properly called physiological, biological, pathological, healthy, or diseased, that can be regarded as wholly physical, mechanical, or chemical in its nature. Thoughtful persons have long felt extremely dissatisfied with the material doctrines of life now so prevalent, and though doubtful concerning the precise terms in which the influence of some non-physical power ought to be stated, have acknowledged that the facts rendered imperative the admission of an agency belonging to an order very different from that in which physical and chemical actions are comprised."

Not to speak of what is desirable as truth, there arises the ennobling contemplation of a spiritual agency—of an all-knowing, all-directing, and everywhere-present Creator. While the physical theory of life cramps the mind and unsettles the faith of the thinking man—

"The doctrine of vitality points in an opposite direction. The mind which contemplates vital power will naturally be led to ponder upon the spiritual. The aspirations of the mind will progressively advance, while the intellect increases in strength, encouraged by the hope that it may succeed in forming some conception of the manner in which ever-present, ever-active power designs, guides, and causes to be carried out the never-ceasing changes in living matter."

Why cannot life be re-called? Because "life would never re-appear unless some power able to overcome ordinary tendencies and capable of setting at nought natural laws intervened."

Anyone reading Dr. Beale's convincing arguments must conclude with him that—

"Vitality is as distinct from matter and material properties as is ever-active mind from the inanimate passive substance which it fashions, and upon which it may impress its own fleeting, and perhaps but momentary, conceptions."

And that—

"A theory of vitality (non-material, psychical) will alone enable anyone to account for the facts demonstrated in connection with the life of all living things. Although an immaterial agency cannot be demonstrated to the senses, the evidences of the working of such a power are so distinct and clear to the reason that the mind which remains unfettered by the trammels of dogmatic physics, and is free to exercise judgment, will not deny its existence."

We have before us in these quotations the opinion of a man not only eminent as an author, but well-known to be a shrewd and careful investigator, who has given years to the examination of the functions of the human frame. The account of the researches as to the construction of living tissue is most interesting. Dr. Beale shows that there are two states of matter in living beings; one manifesting truly vital phenomena, nutrition, growth, and multiplication, while the other is the seat of physical and chemical changes only. It appears that of any living being, but a part of the matter of which it is constituted is really living at any moment, and that in the case of adult forms of the higher animals and man, indeed only a very small portion of the total quantity of their body-matter is alive at any period of existence. The living matter or *bioplasm*, in which wonderful changes occur as long as its life lasts (which changes cannot be explained by physics and chemistry), can be examined at any time, and the principal and most remarkable phenomena can be demonstrated with the aid of a $\frac{1}{12}$th of an inch object-glass magnifying 700 diameters. *Bioplasm* exists in all living beings, and upon it their structure, composition, and actions depend. "There is not," says Dr. Beale, "at any period of life, in health, or disease, a portion of any tissue of man's body the size of a pin's head, with perhaps the single exception of the teeth of the adult and in old age, that does not contain some of this living matter or *bioplasm* in which purely vital phenomena take place. Every tissue may be divided anatomically into elementary parts. Each elementary part consists of the *living matter* or *bioplasm*, and the lifeless formed matter (cell-wall, envelope, tissue, intercellular substance, periplastic matter) produced at the moment of the death of the particles of the first. *Formed matter* accumulates in the tissues as age advances, and thus interferes with the free access of nutrient matter to the bioplasm." In examining tissues under the microscope, it is a very advantageous fact that the bioplasts, the germ of each cell, may be artificially and permanently coloured by an ammoniacal solution of carmine, and thus every particle of living matter in a tissue can be clearly distinguished. And what will be seen, say in a small portion of the thick layer of epithelium covering the papillæ of the tongue, is a number of little particles of living matter, often less than the 1-2000th of an inch in diameter, separated from one another at tolerably equal distances by the material they have produced. These living bioplasts attract through the pores of the lifeless matter already formed by them materials suitable for their nutrition. Thus we can see how the new elementary parts gradually grow up from beneath and supply the place of the old ones which are cast off from the free surface. But these phenomena cannot be explained by physics and chemistry, or without calling in the aid of the hypothesis of vital power. "Elements which have the strongest affinity for one another are separated from their combinations, and, perhaps, made to combine with elements with which they have no natural tendency to unite; and all this is effected, not as we see it done in the laboratory by the skilful chemist after prolonged experience and with the aid of complex contrivances, but silently, and, as it were, by a *fiat*, without any apparatus whatever."

It cannot, then, be said that the matter of the world and its material forces necessarily give rise to the development of life; *life* must be regarded as transcending mere matter and its forces—a later gift of an All-Wise Omnipotence.

PROGRESS IN SCIENCE.

MINING.

AMONG the many difficulties with which the miner has to contend, some of the gravest are those which beset his attempts to carry shafts through water-bearing strata. It unfortunately happens, however, that the Permian beds, which extend over large areas of our coal-measures, are often so highly charged with water that the operation of piercing them in sinking a pit-shaft becomes a task not only ruinously expensive, but fraught with the greatest danger to life and limb. Nevertheless, the future development of our coal-fields must depend in great measure upon the possibility of winning coal from beneath these newer rocks; and, consequently, unusual interest attaches to any improvements which tend to reduce the difficulties of such work to a minimum. For some time past Messrs. Kind and Chaudron have been successfully engaged in boring deep shafts through watery ground; and a valuable account of their system as at present practised in Belgium has been lately given to the North of England Institute of Mining Engineers, by Mr. Warington W. Smyth, F.R.S. The peculiarity of this process consists in sinking the pit *à niveau plein*, that is to say, in carrying on the boring while the water is "at full level" in the shaft. By this means no pumping machinery is needed during the boring, and hence one of the chief items of expense is eliminated, whilst safety to the workmen is ensured by conducting the operation at or near the surface, after the manner of boring an Artesian well. Mr. Smyth's observations were made on a pair of pits now being sunk by this process in the concession of Maurage, on the north rise of the Bassin du Centre, in Belgium. The coal-measures are here overlain by a considerable thickness of cretaceous and tertiary strata, consisting chiefly of sands, marls, and chalk, which in the upper part hold a great amount of water. The foundation of the iron tubbing in these pits is to be fixed at a depth of 636 feet. The four or five men employed in sinking each shaft work upon a platform about 16 feet below the surface. At this working floor the shaft is nearly 19 feet in diameter; but immediately below, it contracts to 15·4 feet, and is carried down of this size to the water-level, which is situated at a depth of about 98 feet. No attempt is made to remove the water until the dangerous ground is pierced through; but the work is carried on by boring, while the shaft—which is nothing more than a gigantic bore-hole—remains filled with water up to its natural level. The boring is effected in two or more stages: during the first, a cylindrical hole is made about 5 feet in diameter, and when this has advanced to a depth of 30 or 40 feet, the upper part is enlarged to the full diameter of the pit. The cutting-tool, or *trépan*, consists of a horizontal bar of wrought-iron, armed upon its lower surface with steel teeth, and attached to thick rods of pine, which are screwed together and fastened at the upper end, by a strong flat chain, to one extremity of a simple lever, the other end of which has direct connection with the piston-rod of a steam-engine at the surface. By admitting steam above the piston, that end of the lever is depressed, whilst the other end carrying the rods is elevated; the fall of the boring-tools is secured by their own weight. The cutter for the large bore weighs about 16 tons, while that for the smaller hole varies according to the nature of the ground; but in piercing hard rock—such as flint—may amount to 8 tons. When the watery measures are pierced, the iron tubbing is let down into its place. This tubbing is made in short lengths, or rings, each with a flange above and below. The bottom flange of the lowest ring is securely seated on a bed cut in water-tight ground, and is surrounded on the outside by a wall of tightly-pressed moss. Upon this moss, as upon a cushion, rests a ring, which slides over the previous piece, and upon this sliding tube the tubbing is built up ring by ring. The successive rings are bolted together, and sheet-lead is inserted between the planed faces of the flanges, while the annular space between the rings and the wall of the pit is filled in with concrete. The water is then pumped out of the pit, and additional security is given to the tubbing by cutting a lower seat, and building up a few lengths of tubbing, tightly wedged under the moss-box. By this ingenious system several pits have already been sunk, safely and successfully, through very dangerous ground.

In spite of the spread of scientific knowledge, the aid which geology is capable of lending to the miner appears still to be too often ignored. One of the most glaring instances of unscientific mining has recently been recorded by Mr. Bristow, F.R.S. During the prosecution of his duties on the Geological Survey, he lately came upon a spot near Easton, in Somersetshire, where a shaft, with steam winding machinery in full operation, was being sunk in the vain hope of reaching coal at a depth of several thousand feet *below* the lowest strata of the true coal measures. Commenced in the lower limestone shales, the shaft had entered the old red sandstone, which it penetrated to the depth of 112 yards—every yard carrying the explorers so much further from the object of their search. The want of scientific knowledge is nowhere more strikingly seen than in such futile experiments, which can only result in the useless expenditure of capital and in keen disappointment to the speculators.

Some remarks on the prospect of finding coal to the south of the Mendips have been contributed to the "Geological Magazine," by Messrs. Bristow and H. B. Woodward; and, in the same journal, Mr. S. Sharp has cited several instances of sinking for coal in Northamptonshire almost as absurd as that at Easton. In Northamptonshire, however, the borings have been made in oolitic rocks, beneath which the coal, if it exist at all, must be hidden at depths almost unattainable. Yet a proposal has been recently made to renew workings in a shaft which was sunk several years ago at Kingsthorpe, near Northampton. This shaft, after passing through the great oolite, inferior oolite, and lias, entered the new red sandstone, and eventually attained a depth of 967 feet from the surface. The project was then abandoned, but £30,000 had already been expended upon the workings. Mr. Sharp now calculates that workable coal cannot be expected to occur at less than 4000 feet from the bottom of the present shaft, thus making a total depth of about 5000 feet from the surface. Still, this undertaking, unpromising as it appears to the geologist, is not without its supporters among unscientific speculators.

As a contrast to these examples of ill directed energy, we may point to the results which have recently rewarded the spirited enterprise of Mr. J. C. Dawes, who for many years past has been exploring the borders of the South Staffordshire coal-field. It appears that after seven years' search, at a cost of about £20,000, he has now discovered at the Hales Owen workings a portion of the Staffordshire thick coal, about 14 feet in thickness.

During the past quarter, the Colliery Inspectors have issued their Reports for 1870. These reports may be advantageously compared with the corresponding documents for the previous year. Thus, in 1869, there were 108,000,000 tons of coal raised in Great Britain by 345,446 colliers, whilst in 1870 the production rose to 113,000,000 tons, and gave employment to 350,894 miners. Yet the total number of separate accidents in 1869 amounted to 854, and resulted in 1116 deaths; but in 1870, notwithstanding the greater activity, there were only 830 accidents, resulting in the loss of 991 lives. In other words, one life was lost for every 99,777 tons of coal raised in 1869; but in 1870 not less than 113,900 tons were raised for every life sacrificed. During 1870 there were 56 explosions of fire-damp, whereby 185 deaths occurred; whilt in the previous year, with only 48 explosions, not fewer than 257 lives were lost. It would be difficult to carry the analysis of these reports further without introducing tabular statements unsuited to the pages of this journal.

In the iron-stone mines which are under government inspection, there occurred, during the year 1870, 51 accidents, resulting in 55 deaths. In addition to the statistical information which these official reports contain, there will also be found in them, as usual, much information and many suggestions which cannot fail to be highly valuable to the practical miner.

To a recent number of the "Annales des Mines," M. A. Henry contributes a long paper on the different explosive substances employed in mining. In this memoir he discusses at some length the comparative value and the conditions of safety in the manufacture, transport, storing, and the use of the several explosives which have been introduced as substitutes for gunpowder, namely, gun-cotton, nitro-glycerine, dynamite, dualine, and lithofracteur. It appears unnecessary to give an analysis of this paper; for, although only recently published, it was written upwards of a year ago, and its publication delayed by the unhappy state of affairs which interfered with the regular issue of most of the scientific journals in France.

METALLURGY.

Any mechanical process which may be suggested for superseding the laborious work of manual puddling deserves serious consideration. It may be remembered that, some time ago, Mr. Menelaus, of Dowlais, bestowed considerable attention upon mechanical puddling; but after patient and skilful research he failed to secure satisfactory results. Mr. Samuel Danks, of Cincinnati, now claims to have successfully solved the problem by means of his revolving furnace—a furnace which does not, however, appear to materially differ from some of those previously devised for the same purpose. The fire-grate is supplied with a fan-blast below, and with jets of air from above to ensure perfect combustion of the fuel; whilst a valve serves to regulate the blast, and thus keep the temperature of the furnace under complete control during the process. The gases generated by the combustion are conveyed across the fire-bridge through a cylinder into the revolving chamber. This chamber rests upon rollers, and by means of a toothed wheel may be made to rotate freely. The foundation of the lining of the apparatus consists of a mixture of pulverised iron ore and lime, mixed with water to a proper consistence. Upon this "initial lining," the fettling proper is applied. At first a certain quantity of pulverised ore is introduced and allowed to melt; lumps of ore are then thrown into the molten mass; and, when the liquid has set, fresh pulverised ore is introduced; this process being repeated until the fettling is sufficiently thick. In the experiments at Dowlais, much of the difficulty consisted in producing a suitable fettling; but Mr. Danks asserts that any iron ore containing not more than 5 per cent of silica will answer his purpose. The pig-iron may be charged in either a solid or a molten state. When the iron is melted, the furnace is caused to rotate once or twice per minute during the first five or ten minutes of the operation. A stream of water is injected at a certain point, and a portion of the cinder is thus solidified; this is carried down into the molten iron in a continuous stream. After the temperature has been raised, and the cinder run off, the velocity of rotation is increased, the charge becomes violently agitated, the mass acquires a pasty consistence, and the particles gradually cohere into a ball. During the process some of the rich fettling is reduced, so that the puddled product actually exceeds in weight the pig-iron introduced. It is said that furnaces of this construction are at work with excellent results in several parts of the United States. Reliable information respecting the merits of the invention will no doubt be obtained by the deputation sent to America for the purpose of examining the process, at the instance of the Puddling Committee of the Iron and Steel Institute.

During the last ten years important alterations have been made in the dimensions of the blast-furnaces erected in the Cleveland district. This subject has been discussed by Mr. John Gjers, at the Dudley meeting of the Institute. Although the first blast-furnace in Cleveland was built in 1851 by the late Mr. John Vaughan, there are scarcely any furnaces still in existence in that district which were erected prior to 1859. The old furnaces were built of small size, the earliest having a height of only 42 feet, a diameter at the bosh of 15 feet, and a capacity of 4566 cubic feet. Gradually the dimensions have been increased, and in 1871 furnaces were constructed with a height of 95 feet 6 inches, a diameter at the bosh of 24 feet, and a capacity of 28,950 cubic feet. Indeed, one of the furnaces erected in the previous year held not less than 41,149 cubic feet. In the opinion of the author, the useful maximum both in height and in diameter have been already attained, if not, indeed, exceeded. Within certain limits, however, increase of size leads to increase of make, to economy of fuel, and to improvement in the quality of the pig-iron. The author proceeds to give a detailed description of the Ayrsome Iron Works, on the River Tees. Two furnaces are already in blast, and two others will probably be ready for blowing in the spring. The furnaces are closed by a cup-and-cone arrangement, and the waste gases are carried down to an underground culvert. Each furnace has a height of 85 feet, and a maximum diameter of 25 feet.

A subject somewhat akin to this, but more local in its bearing, was brought forward at the same meeting by Mr. T. W. Plum, in his paper "On Increasing the Height of Blast-Furnaces in the Midland Districts." The four Old Park furnaces, built half a century ago, were each 45 feet high; but a new furnace, 60 feet high, has recently been erected in place of one of these old forms, whilst an additional height of 15 feet has been given to another of the furnaces by carrying up a casing outside the former tunnel-head. Hence there are now two 60-feet furnaces and two 45-feet furnaces working side by side. At the time the paper was read, but little experience had been obtained respecting the comparative merits of the two forms of furnace; but even from the results then in possession of the author, he felt justified in concluding that a considerably increased yield had been effected by the increased height, and that in districts where tender cokes were used a height of 60 feet might, under existing conditions, be safely attained, but not perhaps exceeded.

From some recent experiments on the evolution and appropriation of heat in blast-furnaces where raw coal is employed, Mr. I. Lowthian Bell is led to conclude that in the Ferrie self-coking blast-furnace, which has been worked with very economical results, one-half of the saving of fuel may be referred to the increased height of this furnace, and the other half to the combustion of the inflammable gases in the flues constructed in the upper part of this form of furnace.

Mr. Barclay, of Kilmarnock, has proposed certain improvements in the construction of blast-furnaces, whereby a considerable saving of fuel is said to be effected. An annular flue, concentric with the shaft, is constructed in the masonry near the top of the furnace; and a portion of the gases escaping from the upper part of the charge gains access to this flue by a series of radiating passages. A number of vertical pipes arranged around the furnace serve to convey these gases downwards to a lower level, where they enter another annular flue; and, becoming ignited by contact with jets of atmospheric air, again enter the furnace. The heat evolved by the combustion is thus imparted to the materials of the charge, while the admission of air is so regulated that no oxidising action is exerted upon the contents of the furnace.

Some valuable researches on the composition of the gases evolved from the Bessemer converter during the blow have been undertaken by Mr. Snelus, of the Dowlais Iron Works. Analyses were made of the gases given off at different periods of a blow lasting eighteen minutes, and the author thus seeks to gain some insight into the nature of the process which goes on within the converter. The analyses are presented in a tabular form,* and show the relative proportions of carbon and silicon which are successively eliminated at different stages of the operation.

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* See Chemical News, Oct. 6, 1871, p. 159.

MINERALOGY.

An extraordinary discovery of native iron, apparently of meteoric origin, was made in 1870 by the Swedish Arctic Expedition when exploring the coast of Greenland. It was not, however, until the autumn of last year (1871) that the largest of these specimens were brought to Europe. So much interest is connected with this discovery that it formed the subject of a recent communication from the Embassy at Copenhagen to the Foreign Office. From some remarks made by Mr. David Forbes upon this communication when submitted to the Geological Society, we learn that the largest of these masses of native iron weighs not less than *twenty-one tons* English, whilst the next in size weighs about 9 tons. The former is now deposited in Stockholm, the latter in Copenhagen. The iron contains nearly 5 per cent of nickel, with from 1 to 2 per cent of carbon, thus agreeing in general composition with many aërosiderites. Moreover, this agreement is strengthened by the development of the well-known figures considered to be characteristic of meteoric iron, when a polished face of the metal in question is etched with acids. The masses of iron were lying on the shore between the ebb and flow of tide, resting immediately upon basaltic rocks probably of meiocene age, in which they appear to have been embedded; and it is curious to note that these neighbouring rocks contain fragments and disseminated particles of similar iron, whilst the so-called meteorites in their turn enclosed fragments of the basaltic rock. Are we, then, to believe that the iron and the basalt were contemporaneous—that, in fact, we are here dealing with *fossil meteorites*, the relics of a meteoric shower in meiocene times? Such appears to be the view held by some mineralogists, including Professor Nordenskjöld. More cautious in his conclusions, Professor Maskelyne believes that the question of their origin, whether meteoric or telluric, can be decided only by examining the basalt at a considerable distance from the objects in question, and thus determining whether the metallic iron is disseminated through the entire mass of rock or is confined to the immediate neighbourhood of the masses of iron. It should be remembered that the Swedish specimens are by no means the first examples of what have been recognised, with more or less probability, as fossil meteorites.

Another species has been added to the short list of minerals already known to contain vanadium. Herr Frenzel, of Freiberg, announces the discovery of a vanadate of bismuth to be named *Pucherite*, after the shaft where it was obtained. The mineral occurs in very small rhombic crystals, of a reddish-brown colour, with a specific gravity of about 5·9. The crystals appear to be disseminated in tolerable abundance through the impure carbonate of bismuth now being raised at the workings at the old Pucher Mine, near Schneeberg, in Saxony.

Professor Church has published in the "Chemical News" the analysis of a fine specimen of *Pitticite* from Redruth, in Cornwall. Excluding the water evolved at 100° C. as accidental, the mineral contained as much as 37·25 per cent of arsenic pentoxide, with only 35·67 of ferric oxide. Phosphorus pentoxide was present to the extent of 1·39 per cent, and the remaining constituents were sulphur trioxide 7·98, and water 17·71 per cent.

A molybdate of molybdenum has been discovered in the lead mine of Bleiberg, in Carinthia, and described by Professor Hanns Höfer under the name of *Ilsemannite*—a name suggested by the late Von Haidinger in honour of J. C. Ilsemann, formerly of Clausthal. The mineral occurs in earthy or crypto-crystalline masses, of a black or blue-black colour, soluble in water. It contains $MoO_2.4MoO_3$; and has probably been produced naturally by the action of sulphuric acid upon the wulfenite, or molybdate of lead, well known to occur abundantly in this mine.

The same mineralogist describes a new fossil resin from the coal of Sonnberg, in Carinthia, to be termed *Rosthornite*.

Some researches on the felspars have been published by Professor Streng. In addition to the theoretical views which he enunciates respecting the chemical constitution of this group of minerals, he describes the result of his microscopic examination of two or three special felspars. He is thus led to regard the *albite* of Harzburg as a mixture containing 96·34 per cent of albite, with 3·66 of anorthite, whilst the *orthoclase* of Harzburg, although presenting the crystalline form of a potash-felspar, really contains almost one-half its weight of albite. The well-known *orthoclase* from St. Piero, in Elba, is also rich in soda, and specimens viewed under the microscope are seen to contain albite to the extent of at least one-sixth or one-eighth of the mass. It is needless to indicate the bearing which such facts have upon the theory of the constitution of the felspars as elaborated by Tschermak.

Further information respecting the conditions under which the diamonds occur in South Africa have been sent to this country, and will be duly published in the "Journal of the Geological Society." Mr. Tobin, who has recently returned to England, has brought with him a most interesting specimen, exhibiting an aggregation of crystals of diamond, apparently associated with a small quantity of foreign matter, which may perhaps represent the matrix. The specimen was found at Du Toit's Pan, which appears to be the present focus of the workings.

A mineral from Arendal, in Norway, hitherto regarded as a variety of garnet, has been found by M. Damour to be really an idocrase. The same chemist publishes the analysis of a garnet from the Rancho de San Juan, in Mexico.

M. Daubrée calls attention to the recent discovery of masses of phosphate of lime in the South of France. These masses, although extremely unpromising in external appearance, are sufficiently rich to prompt active search for similar substances elsewhere.

In Mr. Collins's recently published work on the Mineralogy of Cornwall and Devon,* we are presented with a valuable account of the many minerals found in our two western mining counties. The author's position as lecturer to the Miners' Association is a sufficient guarantee for the general trustworthiness of the book. Of course its especial value lies in the detailed lists of localities, but its interest is by no means purely local. Among the most interesting parts, we may point to the chapter on blowpipe reactions, and to the tabular schemes by which minerals are classified according to their most obvious physical characters. The second part of the work is really a dictionary of mineralogy, and contains lengthened descriptions of the species arranged alphabetically, and illustrated by ten lithographic plates of crystals, remarkable for the accuracy and clearness of their outlines.

ENGINEERING—MILITARY, CIVIL, AND MECHANICAL.

Guns.—In the Engineering Chronicles which appeared in the "Quarterly Journal of Science," some reference was made to experiments carried out by Government between the Prussian and English 9-pounder field-gun. The Prussian gun is known in Prussia as a 4-pounder, that being the weight of the round shot it carries; but as it fires a 9·5 lbs. cylindrical shell, it should really be taken as a gun of the latter capacity. Last November, some further competitive trials were carried out at Shoeburyness between these guns; the practice being made against four rows of targets, each having a frontage of 54 feet wide by 9 feet high, the rows being placed 60 feet apart, one beyond the other, thus giving a depth from front to rear of 180 feet. At a distance of 2500 yards, the Prussian gun (breech-loader) with common shell, made in ten rounds a total of 144 hits, whilst the English gun (muzzle-loader) made only 107 hits. With shrapnell shells the respective performances were, with the Prussian gun 125 hits, and with the English gun 312 hits. At a range of 3000 yards, the effective performances with common shells were 21 hits and 38 hits respectively, and in subsequent experiments with shrapnell shell, the

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* A Handbook to the Mineralogy of Cornwall and Devon; with Instructions for their Discrimination, and Copious Tables of Localities. By J. H. Collins, F.G.S., &c. Truro and London, 1871.

English gun gave still higher performances. From these experiments it has been shown that the Prussian gun had reached its maximum range at 3000 yards, as the curve of its trajectory is very high, whilst the trajectory of the English gun being much flatter is much in favour of the latter.

During the last quarter the new 35-ton 700-pounder gun, known as the "Woolwich Infant," has passed through the last stage of its trials at the proof butts, Woolwich Arsenal. At first the diameter of this gun was 11 6 inches, with which bore it gave very singular and uncertain results as regards pressures and velocities, and it was found not to consume the whole of its powder. In order to remedy these defects the bore was enlarged, by which means it was anticipated that the whole of the charge, being shortened, would be consumed, and that better results would be obtained. In its altered state it was tried, last October, with 110 lbs. and 115 lbs. powder charges and a flat-headed 700 lbs. projectile, when the highest initial velocity obtained was 1355 feet per second with 115 lbs. of Belgian S.G. powder, the highest with Waltham L.G. powder being 1300 feet per second; but as the pressures with the Belgian powder were much higher than those given with the Waltham powder, even proportionately to the velocities, that disadvantage may be considered to more than counterbalance the slight increase in velocity. The carriage for this gun was designed by Captain R. A. E. Scott, R.N., upon his compound pivotting principle. The skeleton of the carriage is of cast-iron, plated with wrought-iron, weighing 11 tons, with gear complete, and measuring 9 feet in extreme length at the base. The gun is carried in a saddle-piece, the ends of which work in slides in the cheeks of the carriage, and have a step arrangement for giving the gun three different planes of elevation. The results were, on the whole, satisfactory, notwithstanding some slight defects discovered themselves, which were due chiefly to the manner in which the carriage was mounted. On the 5th of December, when the last rounds were to be fired previously to its removal to Shoeburyness, a defect was discovered in the steel lining of the bore. We shall have more to say on this subject when we give an account of the further experiments at Shoeburyness, which will shortly be carried out.

Mr. Bessemer has recently published an account of his monster gun, by which the inventor anticipates that a weight of metal may be thrown far in excess of anything that has yet been attempted, combined, at the same time, with a lighter form of gun, requiring the employment of less metal in its construction. To achieve this end, he seeks to consume his powder charge in such a manner as to utilise the whole of its effective force, and, at the same time, to avoid throwing any sudden and excessive strain upon the gun. In the present system a given charge of gunpowder may exert at the moment of explosion a force of 60,000 lbs. per square inch on the chase of the gun, and by the time the projectile has traversed a distance of 10 feet, the pressure may be reduced to a mean of 15,000 lbs. per square inch through the entire length. Mr. Bessemer proposes to substitute for this violent and unequal action a continuous force of only some 3000 lbs. to the inch, maintained upon the shot throughout the entire length of its extended travel along the bore of the gun, hoping to obtain an equivalent duty with a vastly reduced strain. The inner tube of the gun may consist of several thick plates of iron, each bent into a tube, and welded, the inner and outer surfaces being bored and turned so as to receive a series of steel hoops placed on hot, and exerting an initial force on the gun. At the ends of the inner tubes are flanged hoops for the purpose of connecting the several lengths together by bolts. The breech may be secured by a movable breech plug screwed into the end of the tube, and made gas-tight by an expanding metal elastic cap, forming a knife edge on the plug, and forced against a ring of copper, or other soft metal, let into a groove formed around the breech for that purpose. In order that a continuous supply of gas under pressure may be generated and made to act on the projectile as it advances, a cartridge or powder chamber is provided, which fits loosely inside the gun; it consists of a cylindrical mass of steel, in which a large number of small holes or chambers have been drilled parallel to the axis of the gun. From 20 to 100 of these chambers are made according to the size of the ordnance, and varying from 2 to 5 inches in diameter, into which the explosive material is placed. By preference, Mr. Bessemer recommends the use in each chamber of a number of separate charges of powder, separated from each other by diaphragms having a fuze for communicating the ignition, or else parted by a thin layer of meal powder. The quantities of powder in these charges increases at every succeeding discharge of the series, and the intervals of time between the discharges diminish, so as to keep time with the increasing velocity of the projectile, and thus keep up the pressure in its rear nearly uniform throughout its entire movement from the breech to the muzzle of the gun. By this means, it is expected that a projectile may be thrown whose weight may be measured by tons, which clearly could not be effected under the present method of gun construction.

Torpedoes.—At page 292 of our last volume, we gave a brief account of torpedoes adopted by the English Government. The Harvey torpedo has since then fully maintained the high opinion we then expressed regarding it, and it would appear to be the one finally adopted for purposes of attack. The Germans, also, have recently introduced a similar offensive weapon in their fleet, and three boats are stated to be now under construction in Devrient's Dockyard at Dantzic, the destination of which is to place torpedoes under, and thus to destroy an enemy's ship. These boats are built almost entirely of iron, and, being about 60 feet long and only 6 or 7 feet broad, they have nearly the form of a fish. The deck is not flat, but round, so as to be but little exposed to damage from an enemy's shot; and, while employed in active operations, no one will be visible on board. These boats will be steered from the bows; and on the deck, above the rudder, there is a slight elevation to allow the steersman to stand on his feet, and a small opening, about an inch wide, to serve him as a look out. As they are intended to operate close to an enemy's vessel, the armour will be as thick as is consistent with high speed. The most curious part of the invention, perhaps, is, that these tiny screw-steamers use petroleum as fuel, which is contained in a number of iron receptacles in the stern, of sufficient thickness to be impervious to projectiles. The chimney is so small that it can scarcely in any case be hit. The hold for the torpedoes is in the middle of the boat, as well as the quarters of the crews.

Pulverised Fuel.—Many devices have from time to time been put forward with the view of utilising small coal. Amongst others, may be noticed that of pulverising it and burning it as a jet, mixed with air. In the year 1831, one J. S. Dawes took out a patent in this country for applying pulverised fuel to the blast-furnace through the tuyeres; it, however, proved unsuccessful, owing, doubtless, to the fact that the agency of fuel in the blast-furnace is chemical as well as physical. In 1846 a patent was taken out by one Desboissiers for pulverising fuel and blowing the dust into the furnace, but though the conception involved some correct ideas, the machinery was totally impracticable. In 1854 Mouchel suggested the injection of powdered fuel and ores, either separately or together, upon a hearth or inclined plane of a cast-iron box, heated by waste heat from other furnaces. Mushet proposed, in 1856, to use pulverised coal, carried by a blast into a reverberatory furnace to produce the oxidation of the iron. More recently still, Crampton has taken up the subject, and achieved tolerable success in the combustion of powdered coal for locomotive and other steam purposes. The plan, however, which appears hitherto to have been attended with the greatest success, is one by Messrs. Whelpley and Storer, of Boston, at whose establishment pulverised coal is applied to metallurgical and other purposes. A description of this method has recently been given by Lieutenant C. E. Dutton, U. S. Ordnance Corps, in a paper read before the Franklin Institute, from which the following particulars have been taken. One great improvement in Messrs. Whelpley and Storer's process is, that the pulverising and blowing of the fine coal into the furnace is effected by one and the same machine. "Conceive an ordinary blowing-fan with the following modifications." We are now quoting from Lieutenant Dutton's paper. "The box is about 18 inches in diameter, and about the same length. Instead of opening at both ends, one end is tight round the journal. The box is divided into two chambers by a diaphragm, so that, really, we have two fans on the same shaft, and their boxes communicate by a hole in the diaphragm around the shaft. The fan at the closed end of the box is in form and function a blowing-fan. The outer fan is the pulveriser. The coal, fed into the open end of the pulverising chamber, is caught by the swiftly revolving paddles, and reduced to powder, and is then sucked by the fan through the diaphragm, whence it is expelled by the ordinary tangential pipe along with the blast. The coal is fed in the form of coarse gravel; it is delivered as fine as flour. The function performed by this machine is a double one. It pulverises the fuel, and delivers it, along with the blast, into the combustion chamber, by a single and indivisible operation." It has been ascertained from practice that the most suitable velocity for the pulveriser is about 10,000 feet per minute for a point on the periphery of the paddle, which, for an 18-inch pulveriser, would be about 2100 or 2200 revolutions per minute. The feed of fuel must, of course, be determined primarily by the requirements of the furnace, and the minimum quantity that will effect the desired temperature should, in each case, be determined experimentally. The amount of air admitted should be sufficient to float readily the pulverised coal, and no more. If excessive, the increased draught through the pulverising chamber will float out much larger particles than can burn effectively. Generally speaking, it is advisable to keep the supply of air quite small. The 18-inch pulveriser, commonly applied to furnaces, reduces 200 lbs. per hour of anthracite coal, the proportions of size being about like the yield of millstones. It requires about 3½ horses' power to effect this. The same power reduces about 300 lbs. of bituminous coal, a large proportion of it being very fine. The entire yield will burn easily, wafted through a hot furnace. A 42-inch pulveriser, requiring about 15 horse-power, will deliver 1000 to 1200 lbs. of anthracite per hour, 2000 lbs. of bituminous coal, 2500 to 3000 lbs. of quartz, 2000 to 2500 lbs. of top cinder, 3500 to 4000 lbs. of limestone, 900 lbs. of unburnt bone, and 50 bushels of wheat.

Patent Gas.—It is some time since any radical change has been introduced in the manufacture of coal gas. Dr. Eveleigh has recently succeeded, not only in manufacturing a gas purer than is generally obtainable, but he likewise converts the residual products into permanent gas in a manner at once practical and economical. The process introduced by Dr. Eveleigh consists of the distillation of coal in iron retorts, at the comparatively low temperature of 900° (Fahrenheit). The hydrocarbon oils go over with the gas, and they are carried together to a condenser, where the oily matters are rapidly condensed, the gas passing on to its own condenser and purifier. The hydrocarbon oils are collected and passed first into a heated pan, where they are re-vapourised, the vapours being conducted to a re-distillation retort charged with charcoal, and heated to a temperature of about 1200° (Fahrenheit). By passing these vapours through charcoal, it is found that they are decomposed and converted into a permanent gas, which, however, is of a lower illuminating power than that produced directly from the coal. This secondary gas is passed through a condenser, from whence it is conducted through a receiver containing the primary gas with which it is mixed, the union of the two giving a gas of very high illuminating power. Dr. Eveleigh's experience during a long course of trials at his works is, that the retorts, the heating pans, and the re-distillation cylinders require only two-thirds of the quantity of fuel employed in the ordinary process, owing to the superior quality of the coke produced. As regards the results of working, he finds that 1 ton of Pelaw Main (Newcastle) coal, without the aid of Cannel, produces 11,000 cubit feet of 18-candle gas, with only 2 grains of sulphur in any form in 100 cubic feet, or about one-twentieth of that usually found. By slightly increasing the distilling heat, 12,000 cubit feet of 17-candle gas can be obtained from the same quantity and description of coal as above, but with a slight increase of sulphur, not, however, exceeding 5 grains. The yield of oil is found to be twenty gallons per ton of coal, and in its re-distillation two valuable products are obtained in addition to the gas. One is the pitch, which has been assessed at a very high market price; and the other is a drying oil, which is of value for varnishing or painting external work, especially for iron work, either exposed to the atmosphere or submerged in water. There appears to be no difference in the quantity of ammonia obtained, but it is stated to be produced in a better, purer, and more marketable form.

Mont Cenis Tunnel.—We have on several former occasions referred to the operations in connection with this *chef d'œuvre* amongst engineering works, and its course of progress has thus been duly noted. On the present occasion, when we have to record the final completion of this gigantic undertaking, it may not be uninteresting at the same time to note a few of the leading particulars regarding it. On the last day of August, 1857, Victor Emmanuel fired the first blast on the Italian side of the tunnel. On the 25th of December, 1870, the headings from either end met under Mont Fréjus; and the official inauguration of the tunnel took place on Saturday, the 16th of September last, when Italian ministers passed through it from Bardonnèche to receive French congratulations at Modane. The length of the tunnel is 13,364 yards, or rather more than 7½ miles, and its sectional area is 71¾ yards, so that about 960,000 cubit yards of rock had to be excavated and carried to spoil with an average lead of 1·875 miles. The weight of the mass of excavation could not have been less than 2 millions of tons, representing a work of 3¾ millions of ton-miles in the carriage to spoil. The ground cut through by the tunnel may be divided into six zones. 1. The anthracite zone that is first followed in leaving Modane, after traversing 420 feet of loose earth, and which is the most elevated in the order of superposition of the beds. It represents an oblique thickness of 6456 ft. 6 in., corresponding to a real thickness of 3732 ft. 6 in. 2. The quartzite zone, 1251 ft. 3 in. thick, following the axis of the tunnel, and of an absolute thickness of 725 ft. 6 in., the thinnest and best defined of all. 3. The gypso-calcareous zone, of an oblique thickness of 2815 ft. and an actual depth of 1627 ft. 3 in. 4. The upper calcareous zone, which has an oblique thickness of 9104 ft. 10 in., and a normal thickness of 5263 ft. 11 in. 5. The middle zone of calcareous schist which the tunnel traverses for 8563 ft., and the thickness of which is 4950 ft. 6 in. 6. The lower zone of calcareous schist, which extends to the Bardonnèche opening of the tunnel. Its oblique thickness is 11,482 ft. 11 in., corresponding to a depth of 6638 ft. 8 in. The total cost of the tunnel amounted to 65 millions of francs, of which Italy will pay something less than 20 millions of francs, and France will have to pay 25,500,000 francs.

Ballooning.—During the late siege of Paris, no less than fifty-four balloons left that city between the 20th of September, 1870, and the 28th of January, 1871, charged with letters and despatches; the letters thus transported being about 2,500,000 in number, and weighing altogether about 10 tons. Besides this freight about a hundred persons were conveyed from Paris by these postal balloons. The principal dimensions of these balloons were as follows:—Diameter, 51 ft. 8 in.; superficies, 8390 square feet; and contents, 72,240 cubic feet. The balloons were of a spherical form, and were made of highly glazed calico varnished, each being composed of forty gores. The gores were cut to shape with perfect regularity, and were strongly sewn together with a coarse double waxed thread. This being done, the exterior received two coats of varnish, and then as soon as the balloon was dry it was ready for inflation, ordinary coal gas being employed for the latter purpose. In the lower aperture of the balloon was fitted a wooden ring, 2 ft. 7½ in. diameter, which was united to the sheet-iron pipe, 5 ft. long, which placed the balloon in communication with the gas pipes. Above, the balloon was fitted with a valve, consisting of a ring of oak, 2 ft. 7½ in. in diameter, provided with a couple of semicircular valves, kept close by india-rubber bands, and arranged so that they could be opened by means of a cord which passed down to the car through the interior of the balloon. The balloon was enveloped and connected to the suspension ring by strong tarred hempen cords, while the suspension ring, which was 3 ft. 3½ in. in diameter, by 3·2 in. high and 2 in. thick, was provided with *gabillots*, to which were attached the eight cords of the car. The latter was made of wicker work and Indian reeds, and was 3 ft. 7½ in. deep, by 4 ft. 7 in. long, and 3 ft. 7½ in.

broad, whilst the distance between it and the suspension ring was 6 ft. 7 in. The total height of each balloon was 68 ft., and its weight 913 lbs.

Sewage Works.—On the 23rd of October last the sewage irrigation works at Leamington, which have been constructed at a cost of £16,000, were formally opened. The sewage has all been taken by the Earl of Warwick, who has undertaken to dispose of it for a term of thirty years, for which purpose he has laid out a farm of 1000 acres on his estate. The population of the district, according to the last census, was 23,429. In order to raise the sewage, two condensing beam engines have been erected at the pumping station, either of which will pump 1,500,000 gallons in twelve hours; but in ordinary weather it is expected that one pair of pumps will be sufficient. At the preliminary trial, one engine pumped 20,000 gallons of sewage in an hour and a-half.

The Sewage Inquiry Commission appointed to inquire into the question of the best means of disposing of the sewage of Birmingham has recently issued its report. The town of Birmingham stands almost on a ridge of high land, and is remote from any large river. Hitherto almost all its sewage has been drained into the small river Tame, polluting its waters to such an extent, that the Right Honourable Sir C. B. Adderley, through whose estate the contaminated waters run, has obtained an injunction from the court of Chancery to restrain the Corporation from continuing to poison this river, and hence the appointment of the Commission. The population of Birmingham is 345,000, and the number of houses in the borough is 73,200, having an average of 59 persons to an acre on the area built upon. The average dry weather flow is 17,000,000 gallons per day, notwithstanding that not more than 20,000 persons are accommodated with water-closets, leaving 325,000 dependent on the open middens with which the town abounds, and which together cover an area of no less than 13½ acres. Analysis of the water in the wells, from which not less than 105,000 of the population are entirely dependent, shows that it consists in reality of filtered sewage. Thus the Birmingham Town Council have to deal with their sewage in such a way, not only to meet the requirements of the court of Chancery, but also to improve the sanitary condition of the town itself, whilst, as there exist no means of disposing of the sewage in an unpurified state, some mode of purification becomes a necessity. From the inquiries made by the Commission from other towns they report as follows:—1. That the land improves greatly under irrigation. 2. That as a rule, no complaints are made of nuisance arising therefrom. In the few instances in which nuisance has arisen, it has been the result of carelessness in conducting the irrigation. 3. The health of the district where irrigation is carried on is not injuriously affected. 4. Cattle thrive on the irrigated land, and no case of their being affected with entozoa has ever been heard of. 5. No other manure has been found necessary for the crops, and the produce, both in quality and quantity, is very satisfactory. 6. The water, after passing through the land, is purified in a satisfactory manner, and in one case cattle drink the effluent water. As at least 10,000 acres would be required to deal with the sewage by irrigation—an extent of land which could not be procured for that purpose—the Commission recommend that 800 acres of land should be purchased, and the purification of the sewage be accomplished by a simple system of downward filtration. The outlay required for this purpose is estimated at £14,160, and the returns at £9,200, thus leaving an annual deficit of £4900, which would have to be made up by local taxation.

Extensive works are now being constructed by the Native Guano Company at Crossness, with a view to utilise a portion of the sewage of the Metropolis by means of the A B C process. The daily outfall of sewage at Crossness is about 50,000,000 gallons, or more than 223,000 tons; at first, however, the Native Guano Company propose to deal with only about 500,000 gallons in the twenty-four hours, which will be drawn from the culvert through which the sewage flows into the great reservoir; and from this point the sewage will flow through a large pipe into the sump of the engine on the Company's works. From this the sewage will be pumped into the mixing room, where there is a cylinder and four A B C mixing pits, all fitted with mechanical stirrers. The cylinder contains one minute's supply of the sewage, which enters at the bottom, and rising with the A B C mixture, whilst being gently stirred overflows by a trough into the settling tanks. The four mixing pits are fed by troughs from a crushing mill, in which the ingredients of the A B C mixture are pounded up with from 82 to 84 per cent of water. The mixture is kept stirred in these pits, and is drawn from them by gravitation into a small pumping well, fitted with duplicate earthenware pumps, each capable of throwing a quantity of mixture equal to from ½ to 1½ per cent of the sewage to a hopper, placed at such a level that it flows thence by gravitation into the rising main containing the sewage at the point where it enters the mixing cylinder. 10,000 grains of raw sewage are to be mixed with from 10 to 18 grains of the A B C ingredients, exclusive of water. The compound comprises from 2 to 3 grains of crude sulphate of alumina, 3 grains of animal charcoal, 10 grains of clay, and a fraction of a grain of blood. As soon as the mixture enters the settling tanks it begins to throw down the precipitate. Each tank when full is allowed to remain for six hours, and at the end of that time the floor will be covered with a deposit of sewage mud, while all above will be clear water. The water will then be run off and passed through filter beds, from which it will flow into the river. The mud will then be run off into covered acidifying tanks, where, after further settlement, and removal of more water, it will be treated with sulphuric acid, in the proportion of 1 pint of acid to a ton of mud, in order to fix the ammonia. The mud is then dried on an iron floor closely roofed in, the products of combustion from the furnace passing over it, and which, together with the steam exhaled by the mud, is passed into a vessel or tank, where it is made to pass through water in order to remove any noxious properties before escaping into the air. It is computed by the company that the 500,000 gallons of sewage to be treated daily at Crossness will result in the production of 4 tons of native guano.

TECHNOLOGY.

Dr. Jeannel has recorded the results of a series of experiments, from which it appears that food, both animal and vegetable, boiled at 95° is more nutritious and of better flavour than when boiled at or above 100°. The author illustrates this point by referring to the experience gained in mountain localities (every 100 metres' rise above sea level make a difference of ⅓° C. less in the boiling-point of water); as, for instance, at Potosi, at 4061 metres above sea level, and an average barometer reading of 454 m.m., the water boils at 86·2°; at Mexico, 2277 metres above sea level, 569 m.m. barometer, water boils at 92·1°; at Briancon, 1321 metres above sea level, 643 m.m. barometer, at 95·4°; these results are also confirmed by the action of the so-called Norwegian cooking apparatus.

The utilisation of crude petroleum for fuel has attracted the attention of many scientific men. The great aim is to discover a process whereby the tendency to carbonisation should be overcome. This difficulty an American inventor has now overcome. From the "Chicago Evening Mail," we learn that his apparatus consists of a cylinder, like a small locomotive boiler set on end, with a smaller cylinder within it, the intervening space being filled with petroleum. The smaller cylinder is filled with six hundred small copper tubes, and through these superheated steam passes, producing vapour from the oil that fills the interstices between the tubes. This vapourised oil rises through a layer of prepared sponge, and just at the point of exit is mixed with superheated steam in any required proportion, thus producing hydrocarbon gas. This gas passes through iron tubes to the point where the fuel is needed, and is there burned, very much like common gas. In the case shown in illustration the kiln was filled with stone, and in a very short time after the fire was lighted the heat was more intense than can be expressed by comparison. All this time the fire was under perfect control, and by a simple turn of a screw the combustion was made more or less intense. The experiment was varied by admitting a greater or less proportion of steam into the pipes, so that in some cases the fire was fed with fifty per cent or more of water, and the remainder of vapourised oil.

A cheap and good process for the utilisation of leather waste has long been a desideratum. This waste represents millions of dollars annually. A process that could reproduce a texture of these cuttings, only half as good as the original leather, would be one of national importance, and would at once establish a new industry. The "Scientific American" describes a process invented by Mr. P. J. McKenzie Oerting, which is said to make uniformly an artificial leather even superior to ordinary tanned sole leather. Examination of these specimens reveals the following facts:—It is much harder than ordinary leather, and does not yield to hammering or compression nearly as much. It is very flexible and elastic. Thin shavings of it possess as great tensile strength as shavings of equal thickness of common oak-tanned leather. It is nearly, if not quite, impervious to water. It cuts smoothly and easily in working. With regard to its durability under wear, it would probably wear longer than sole leather, as it is said not to decompose or change under the ordinary circumstances of wear to which leather is exposed in its various uses. The method under consideration was first brought out in Copenhagen. The ingredients employed and their proportions are as follows:—For first quality, one pound caoutchouc for each three and a quarter pounds leather pulp. For other qualities, the proportion of leather pulp is increased variously up to six pounds for one pound of caoutchouc. The caoutchouc is dissolved in benzol or other solvents, and, when sufficiently dissolved aqua ammonia is added in the same proportion as that of the rubber, and the mass is thoroughly stirred until it assumes a grayish-white colour. The leather pulp is then added, and the whole is kneaded into a plastic homogeneous dough of uniform consistency, which can be pressed or moulded into any required form, or rolled into sheets, as may be required. The ammonia is said to act upon the animal glue in the cuttings, restoring to it its original properties which it had lost to a great degree in the process of tanning. The following are some of the properties and uses of this remarkable substance, as given by Mr. Oerting:—Its waterproof quality makes it especially valuable for pump leather, as well for cold as hot water, and also for harness, as even a continued exposure to all kinds of weather has no effect on it, occasioning neither rot nor crack. It can be made endless, or of any length, width, and thickness required, and of perfect uniformity as to wear, which is generally well known to be impossible with leather belts made of shorter pieces of different hides, and of unequal wearing capacity. It will stand any amount of heat and friction, as well as the most intense cold, will stretch less than any other belting, and can be changed from one pulley to another with ease and rapidity. It is very strong and substantial in the edge, and will stand a great amount of ill use without suffering any injury, and through its combined properties will supply a desideratum much needed. By suitable machinery for moulding, or forming the material in its doughy state into hose, fire buckets, &c., for which purpose it is especially adapted on account of its flexibility, impenetrability by water, and its capacity to withstand any amount of hardship, as well as extreme heat or cold, it will certainly make the best as also the cheapest material yet produced for such purposes. By a different mixture and proportion of the ingredients, a matting for floor covering is made, which on account of its cheapness, its waterproof properties, and its capacity to keep rooms protected from cold and dampness, makes, it is said, an unequalled article for covering offices, passage ways of public buildings, &c., which will withstand an immense amount of wear, and can very easily be cleaned.

At a recent meeting of the Manchester Literary and Philosophical Society, Mr. John Hopkinson, B.A., D.Sc., detailed some experiments on the subject of the rupture of iron by a blow, the results of which are—1st. That if any physical cause increase the tenacity of wire, but increase the product of its elasticity and linear density in a more than duplicate ratio, it will render it more liable to break under a blow. 2nd. That the breaking of wire under a blow depends intimately on the length of the wire, its support, and the method of applying the blow. 3rd. That in cases such as surges on chains, &c., the effect depends more on the velocity than on the momentum or *vis viva* of the surge. 4th. That it is very rash to generalise from observations on the breaking of structures by a blow in one case to others even nearly allied without carefully considering all the details.

In a paper by Mr. H. Wild on an improved method of filling barometer tubes without the necessity of boiling the mercury and without the danger of breaking the tube, the author describes a method of purifying mercury from zinc and other metals which are not easily removed by distillation. Take 1000 grms. of that metal, pour it into a strong flask capable of holding 2000 grms. of water. Take, next, 30 grms. of a solution of chloride of iron (made up of 1 part of the dry salt and 3 parts of water), add this to the mercury, and, after having closed the flask with a cork, shake it vigorously until the metal is so finely divided that with the naked eye no more globules can be seen. Water is next poured into the flask, and the contents, having been well agitated, are left for a moment to settle, and the impure solution poured of; this operation is repeated twice, after which the greyish mass of very finely divided metal is poured into a porcelain basin, which, having been placed on a water-bath, is made dry, and next brought to its normal state of aggregation by rubbing in a glazed porcelain mortar. The metal is next filtered through good tough writing-paper wherein a perforation has been made with a needle.

Dr. Sézille has described a new process of panification. The wheat is first deprived of its outer cover, or husk, by means of properly constructed machinery; the decorticated grain is next several times acted upon by tepid water at about 80° for the first bath and 40° for the subsequent ones, whereby the gummo-resinous cover of the grain is dissolved and removed. This removal is necessary on account of the fact that this substance becomes very deep brown, almost blackish, coloured by fermentation of the dough; the grain at the same time absorbs from 65 to 70 per cent of water, and is then reduced to a paste by means of machinery very similar to that used in chocolate mills. This perfectly white paste is next leavened, and after fermentation is ready for baking. By this process, from the same quantity of grain which by the usual process only yields 108 to 110 kilos. of bread, the yield is increased to 145 kilos. of very superior quality and far greater nutritive power; moreover, a very considerable saving of labour and expenses connected therewith is effected by the application of this new process, which has been thoroughly tested by competent and independent scientific as well as practical men.

A method of coating metallic objects with a very durable black-brown varnish is given by Dr. C. Puscher. On the bottom of a cylindrical cast-iron vessel, 18 inches high, is placed a layer, ½ inch thick, of coal-dust; upon this is placed an iron grating, and thereon are put the iron, steel, or other metallic objects intended to be coated with the varnish. The vessel, having been first closed with a well-fitting lid, is next placed on a bright coke fire, and heated for about a quarter of an hour just to incipient red heat. The vessel is then removed from the fire, and on the lid being removed, after about ten minutes, the metallic objects will be found coated very uniformly with a good and durable varnish, which resists bending, as well as a high temperature, without cracking or coming off. Very small objects, such as hooks-and-eyes, for instance, are better placed along with some coal-dust in a coffee-roasting apparatus, and this turned, as is usual in the roasting of coffee, until the metallic objects have obtained the desired depth of colour and are uniformly coated with the varnish.

By the use of types made of an elastic material, A. Ae. Wilbaux prints on glass by means of fluoride of calcium incorporated in printing ink; the glass thus printed on is next treated at a suitable temperature with sulphuric acid, and after having been washed with water it contains in an indelible engraving the figures of the types.

An elaborate essay on the pigments and dyes known to and used by the ancients has been published by M. E. Rousset. From the contents it appears that the author's primary object is to prove that the ancients were not so ignorant in industrial matters as is commonly supposed to be the case. Among the white pigments they were acquainted with white-lead, which, according to Pliny, was prepared especially at Rhodes. As black pigments, various kinds of charcoal and soot were used by the ancients, the same as nowadays; while they dyed animal skins black with nutgalls and sulphate of iron. By their acquaintance with the use of various kinds of ochre, and by mixing these, either with each other in various proportions, or with black pigments, brown pigments of various shades were obtained. Under the name of Alexandria blue, the ancients (the author includes in that term the ancient Egyptians, as well as Greeks and Romans) largely used a pigment containing oxide of copper, and they also were acquainted with a pigment containing cobalt. Indigo was not unknown to them, but it was not used for dyeing, their blue-dyed fabrics being obtained by the use of pastel-wood, *Isatis tinctoria.* They used the following yellow pigments:—Ochre, massicot, orpiment, and realgar; the latter are poisonous, and do not cover well; the former are devoid of any brilliancy. As to the yellow dyes used by them nothing is positively known, but it seems that woad, saffron, and other native plants were employed. Referring to yellow pigments discovered by modern chemistry, Naples yellow (antimoniate of lead), mineral yellow (oxychloride of lead), and the chromium colours, discovered by Vauquelin (1797), cadmium yellow, discovered by Stromeyer (1817), are mentioned. Among the modern yellow dyes, purrhee and picric acid are enumerated. Vermillion, red ochres, and minium were known from a remote antiquity, though neither Greeks nor Romans were acquainted with the artificial preparation of vermillion, which has been known to the Chinese for a very lengthy series of centuries past. As to red dye-stuffs, there can be no doubt that madder was known and used not only for dyeing fabrics but also in the shape of so-called lake. Kermes, a dye-stuff little known in this country, but yet used in France, was known to and used by the ancients, being undoubtedly used in Egypt in the time of Moses. Among the green paints the ancients were only acquainted with some native green-coloured compounds of copper, and with the acetates of that metal; the number of green pigments discovered in modern times is very large and need not be here alluded to. Of purple dyes known to and used by the ancients, the celebrated Tyrian purple is here at length spoken of. Among the molluscs from which this dye was obtained is the *Janthina prolongata*, yet found in the Mediterranean, and a very common object in that sea near Narbonne (in this very ancient city there were Tyrian purple dye-works at least 600 years B.C.), where in our days some experiments have been made by Dr. Lesson which really prove that the mollusc just named yields, though only in very small quantity, an exceedingly beautiful purple. Dr. Bancroft was also acquainted with this fact, and made several trials for the purpose of ascertaining whether this dye-stuff might be again industrially applied.

A cheap mode of preparing pure dextrine is given by O. Ficinus. 500 parts of potato-starch are mixed with 1500 parts of cold distilled water and 8 parts of pure oxalic acid, and this mixture placed in a suitable vessel on a water-bath, and heated until a small sample tested with iodine solution does not produce the reaction of starch. When this is found to be the case the vessel is immediately removed from the water-bath, and the liquid neutralised with pure carbonate of lime. After having been left standing for a couple of days the liquor is filtered, and the clear filtrate evaporated upon a water-bath until the mass has become a paste; this is removed by a spatula, and, having been made into a thin cake, is placed upon paper and further dried in a warm place; 220 parts of pure dextrine are thus obtained.

Dr. F. Stolba gives the following directions for cleaning glass vessels wherein petroleum has been kept. Thin milk of lime, used for washing glass vessels wherein this liquid has been kept, forms with the petroleum an emulsion, and renders it possible to remove all traces, and, by the addition of a small quantity of chloride of lime to a second washing with milk of lime, even the smell is taken away so completely as to render the vessels fit for pouring and keeping beer therein; if warm milk of lime be used, the operation, which otherwise takes considerable time for completion, is rendered shorter.

MM. Montéfiore-Lévi and Künzel have published a work on the use of divers alloys, and more especially of phosphorus-bronze, for the casting of ordnance and other purposes. In it is given a detailed account of an extensive series of experiments made on the large scale on the preparation of various alloys of copper and tin, and the effect produced thereon by the addition of phosphorus in small quantity. It appears, on the whole, that the addition of this element is of great value in producing alloys possessed of excellent properties, especially for the manufacture of bronze guns. The Academy has appointed a committee of six of its members, among them MM. Dumas and Frémy, to study this important matter, and report thereon.

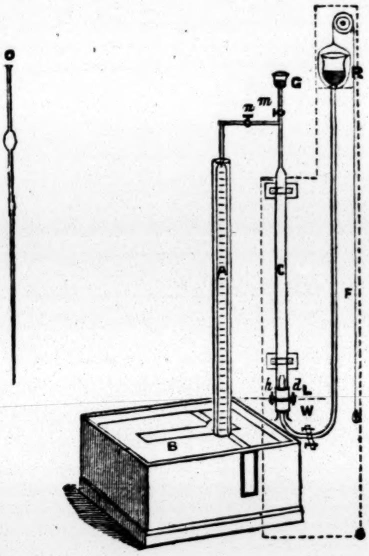
The extraction of animal fats to be used either as food or for cosmetic purposes forms the subject of a memoir by Dr. H. Vohl. The fresh fat is first as much as possible freed from membranes and flesh, next cut up either into small discs or cubes, and then thoroughly washed with cold water, which should contain the least possible quantity of lime, until all blood is entirely removed. The fat is next put into a cylindrical stoneware vessel, 1·25 metres high and 0·5 metre inside diameter, this vessel being placed in a water-bath and provided with a tap at the bottom, so placed that the vessel may be emptied without removing it from the water-bath. The vessel having been three-fourths filled with fat, there is placed on the top of it a stoneware perforated disc, and next very dilute pure hydrochloric acid is poured over it. The stoneware vessel is then closed with a well-fitting cover, and the water-bath heated. From the fat, while melting, the perforated cover carries, by slowly sinking downwards, all the impurities, as far as they are not dissolved by the acid, which at the end of the operation is run off by aid of the tap. The fat is then, while molten, washed several times with warm water, to which, for the last washing, some carbonate of magnesia is added. The fat is next treated with refined petroleum spirit, and the solution separated by decantation from any membranes, &c. which may remain. The solution of the fat is freed by distillation in a water-bath from the petroleum, and the result is the production of a very superior fat, which being absolutely free from water and other nitrogenous organic matter, is not liable to become rancid, and may be preserved for many years.

CHEMICAL SCIENCE.

Dr. J. Lefort has made some important observations on the alteration which well-water undergoes by the proximity of burial-grounds. The contents of this paper bear more especially upon the effect of a decree, dated March 7th, 1808, whereby it was enjoined that no wells should be bored or dug out at a less distance than 100 metres in direction from any burial-ground. The author, having found that not only in many country villages, but also in several towns this regulation was not observed, has made some experiments on the water of a well at Saint Didier (Département de l'Allier). This locality is situated on an alluvial soil; the water is used for drinking purposes by the parish priest and a portion of the inhabitants, and, on examination, the author found it to contain not only a large proportion of ammoniacal salts, but also, on evaporation, to leave a very large quantity of a dark-coloured organic matter mixed with carbonated salts, which, on being mixed with some hydrochloric acid, gave off an offensive carbonic acid gas, the smell being somewhat akin to a mixture of a concentrated solution of glue and butyric acid. The well is very deep, and the water is quite clear and bright, but exhibits, especially in summer time, a very vapid taste, while, in the warm season of the year, it rapidly becomes putrid. The author comes to the conclusion that in any soil a well dug at the distance of 100 metres from either burial-grounds or battle-fields is certain to be so contaminated with organic and other injurious matter as to make it imperatively necessary to make new and sound regulations on this subject, so as to prevent wells (for obtaining potable water for domestic use) being sunk without a stringent inquiry as to where the water comes from, and through what strata of soil it may have to pass.

Mr. J. Parry has devised and carried out practically a new form of gas apparatus, which possesses advantages over those of Bunsen and Frankland and Ward. The measuring or gas tube, A, is enclosed in a glass cylinder filled with water, and dips into the mercury trough, B. The absorbing and eudiometer-tube, C, is connected with A by a well-fitting elastic tubing of double thickness, firmly wired to the capillary glass tubing shown in the sketch. The use of this apparatus hardly requires to be described. By alternately raising and lowering the mercury reservoir, R, both A and C are filled. The gas for analysis being then bubbled up into A, and measured with the usual precaution. The liquid absorbent required is poured into the cup, G; R is lowered, M opened, thus drawing the test into C, a little being left in the cup to prevent admission of air. The tap, N, is now opened, and the gas drawn into C; both M and N are to be kept closed while the gas is being subjected to the action of the absorbent. The latter must always be run into C as described, or it is drawn into the measuring-tube. To clean C the gas is passed back into A, N is closed, and M opened, B lowered, and the mercury and absorbent allowed to flow out to about the level of L (see dotted line). Unscrewing the nuts H and D, the lower part, W, is taken out, the test, &c., falling into a large basin placed under. While the mercury, &c., is falling down the tube, C, water must be poured into the cup, G, for washing out traces of the absorbent. The eudiometer-tube, C, is well washed with pure water, with the pipette, O (which consists only of an ordinary pipette joined to a long glass tube by a short piece of elastic tubing); it is evident the long tube may thus be conveniently passed up C, and the water blown through and up C, flowing down the sides of the tube into the basin. The part W is made of iron or steel of the form shown; a plug of caoutchouc is firmly cemented into the short iron tube; the platina wires for explosions insulated in glass tubing, also the glass tube (wired to the elastic tubing, F, by which the reservoir, R, is raised and lowered) are passed air-tight through the caoutchouc plug. The flanges, &c., W and L, should be well made with smooth true surfaces; a washer of caoutchouc is placed between the flanges, also the end of C presses down on the plug when the nuts H and D are screwed down. By means of this apparatus analyses are rapidly and conveniently done; explosions are accomplished without difficulty, with far less trouble and risk than with the ordinary eudiometer; the gas for explosion may be expanded to any required extent by lowering R, and any risk of bursting C is thus entirely obviated. Water may be substituted for mercury in the trough, B, but of course, with less accurate results. The eudiometer, C, may be supported by clamps attached to a long iron rod, and R raised or lowered by a pulley.

FIG. 8.



Dugald Campbell, F.C.S., has recently analysed some ancient Jewish glass obtained from Bessant, secretary to the "Palestine Exploration Fund," and which, that gentlemen writes, "Is all from shafts *round the Temple*, and found at depths varying from 20 to 80 feet," and as its history is truly interesting and its composition is somewhat curious, an analysis may not be out of place in the pages of this journal. The sample of glass weighed altogether about 3 ounces, and consisted of a number of small pieces, many of which in parts had undergone a change both in structure and colour by time and exposure. The portion selected for analysis was from pieces which appeared to have undergone the least if any change, and the results were as follows, in 100 parts:—

Silica	69·30
Lime	8·50
Magnesia	0·55
Soda	13·79
Potash	1·49
Alumina	3·20
Oxide of iron (Fe_2O_3)	2·00
Oxide of antimony	0·29
Oxide of lead	trace
Phosphoric acid	0·80
Loss in analysis	0·08

The specific gravity of the glass is 2·430.

Wagner, in "Versuchs Stationer Organ," xiii., 69 to 75, and 218 to 222, describes the results of his experiments with kreatine as a source of nitrogen for plants. Maize plants grew and developed seeds in a solution in which kreatine was the only nitrogenous substance present. The kreatine was absorbed unchanged, and was detected in the plants. Wagner refers to the fact that Hampe had found that urea is absorbed unaltered by plants. The same observation was made by Dr. C. A. Cameron in 1857, and was reported in the "Transactions of the British Association" for that year, in the "Chemist," for November, 1858, and in the "Repertoire de Chemie, Pur et Appliqué," Paris, December, 1858. Dr. Cameron finds that plants can absorb unchanged, and apparently derive nitrogen from, potassic nitrite, potassic cyanurate, and potassic ferrocyanide.

An examination of the gases occluded in coal forms the subject of a paper by Dr. E. Meyer. Lumps of hard and compact Zwickau coals (Saxony) the size of a walnut were put into a flask, previously partly filled with thoroughly well-boiled and hot distilled water; the flask was next closed with a perforated caoutchouc stopper wherein a glass tube was fitted, which, serving as gas conveying tube, was carried into a vessel filled with water deprived of air. The apparatus thus arranged was kept at boiling heat for some time in order thereby to eliminate the film of air which adheres mechanically to the coal. The boillng was further continued after the gas-conducting tube had been placed over a graduated glass tube, previously filled with distilled water freed from air and placed on a pneumatic trough. The gas thus collected (constantly evolved from the lumps of coal) was analysed according to Bunsen's method, and found to consist in the first sample operated upon of:—Carbonic acid, 16·9; marsh-gas, 20·4; nitrogen, 53·3; oxygen, 1·7; heavy carburetted hydrogens absorbable by fuming sulphuric acid 7·7 per cent. Second sample—Carbonic acid, 22·4; marsh-gas, 22·3; nitrogen, 48·0; oxygen, 4·1. The large quantity of nitrogen and the small quantity of oxygen deserve special notice. The samples of coal experimented with had been kept in a cellar for a period of several months in contact with air so that it would appear that the oxygen of the air absorbed has served for the oxidation of the coal and formation of carbonic acid.

The presence of manganese has been shown by G. Campani to be a permanent constituent of blood. This subject was taken up by the author in consequence of a paper published in a scientific Italian periodical, wherein Dr. Pollacci asserts that manganese is an integral constituent of blood. It appears from the author's experiments, made with blood of oxen, that the globules as well as the serum contain, along with iron, weighable quantities of manganese.

As bearing somewhat on this subject, we may here record a very delicate test described by Dr. Böttger for the detection of minute traces of manganese. A few grammes of chemically-pure chlorate of potassa are first fused in a test-tube, and, while fused, there is put into it a minute quantity of the substance, mineral or organic, to be tested for manganese. If at the end of the reaction the contents of the thoroughly cooled tube exhibit a peach-blossom red colour, the substance thrown into the fusing chlorate of potassa contained manganese, the presence of which may be thus ascertained in wood, human hair (especially the reddish coloured), coal, and minerals, of all of which only minute quantities are required.

Dr. Roux has published a note on the existence of copper in certain waters. The experiments were chiefly made at the request of the Maire of Saint-Jean-d'Angely (Charente Inférieure), bearing upon the question that some of the spring-water of that town had become impregnated with copper, owing to the waste water of a coppersmith's shop having by percolation through the soil found its way to the spring. The result of very minutely conducted assays of the soil, as well as of the water in the neighbourhood of the works, revealed the presence of copper, but only in very small quantity. Water from Rochefort, pumped up by the aid of copper pumps, contained rather more copper; but in neither case was the quantity of that metal found in the waters alluded to so large as to be capable of giving rise to any injury to health, the less so as the French, by daily using copper cooking-vessels, obtain from these a sufficient quantity of copper in their system to render the detection of that metal in their blood an easy matter.

In the gold mines at the Thames, New Zealand, there are found tolerably large quantities of grey antimony ore, or stibnite, associated with the quartz and other rocks of the older series, from which gold is extracted. Mr. Pattison Muir has examined a sample of this stibnite. It has the appearance of a large mass of steel-grey crystals, radiating chiefly from a central point, some of the crystals being fully an inch in length, and generally very perfectly formed. The crystals are prisms belonging to the trimetric system, soft, and easily cut with the knife in the direction parallel to the principal axis, showing, when cut, a brilliant metallic lustre. Adhering to the crystals is a small amount of gangue, composed seemingly of siliceous matter. For the purpose of analysis a large crystal was broken off perfectly free from any foreign matter. The specific gravity of the crystals = 4·625. On analysis it was found to contain—Antimony, 71·09; iron, 0·24; arsenic, traces; sulphur, 28·47 per cent.

In making some experiments on the action of sulphur on paraffin, Mr. John Galletly found that a mixture of these substances, either in equal parts or with a larger proportion of sulphur, when heated in a flask not greatly above the melting-point of the sulphur, begins to evolve hydrosulphuric acid, and continues to give off this gas steadily, while kept moderately heated for a considerable time. This process is a most convenient one for laboratory use. With a round flask holding about a pound of the materials fitted with a tube bent at right angles about ½-inch bore and 12 to 18 inches long, containing a little loose cotton-wool, and having a smaller tube fitted to the end of this for dipping into the liquid through which it is desired to pass the gas, a convenient stream can be obtained lasting several days. The production of the gas can be stopped and renewed at pleasure by withdrawing or applying the heat. An Argand lamp should be employed, or if a Bunsen is used, the top piece should be on the tube for spreading the flame, so as to avoid heating on one spot. Heavy paraffin oil used for lubricating machinery can be substituted for the solid paraffin, and good results are also obtained with commercial stearic acid, but with the latter the tube conveying the gas soon becomes covered with drops of a milky liquid, which is probably water and finely divided sulphur. With paraffin the tubes remain clear and bright, except for a little sulphur sublimate close to the neck of the flask. Reinsch recommends a laboratory process for obtaining pure hydrosulphuric acid by heating in a glass flask equal parts of sulphur and suet. The recommendation does not seem to have been generally followed, but the advantages resulting from the substitution of paraffin for suet may lead to the more usual adoption of this process.

Drs. K. Kraut and O. Popp have described a series of experiments made with solutions of carbonate of potassa of different strength, into which sodium amalgam was placed and left for a longer or shorter time, the result being the formation of a crystalline potassium amalgam, mixed, however, with a very small quantity of sodium, which the authors consider to have been left in combination with the mercury. The percentage composition of several of the amalgams thus obtained is quoted; as instances, we mention the following:—Hg, 98·370; K, 1·560; Na, 0·036. Hg, 98·420; K, 1·31; Na, 0·119. Hg, 98,044; K, 0·934; Na, 0·641. Potassium amalgam—formula, K_2Hg_{24}; in percentages—Hg, 98·41; K, 1·59. Sodium amalgam, Na_2Hg_{12}, containing 1·88 per cent sodium.

Dr. Berthelot, who has worked long and successfully on the chemistry of the different varieties of carbon, has now treated on the properties of the carbon met with in the Cranbourne (near Melbourne, Australia) meteorite. This carbon must be considered as having been first in state of solution in molten iron, and to have separated therefrom on cooling. Next, the carbon obtained from oxide of carbon, by the decomposition of that gas by iron at a relatively low temperature, is considered. From the reactions of these substances, the author comes to the conclusion that native graphite, about the origin of which very little is known, is certainly not, at least as far as experiments can throw light on this point, derived from either anthracite or from decomposed masses of meteoric iron which contained carbon.

The presence of milk sugar in a juice of vegetable origin has been demonstrated by Dr. G. Bouchardat, who has examined a specimen of sugar obtained (1837) from the juice of the *Achras sapota*, at Martinique, the specimen being preserved among the objects known as belonging to the *Matière Médicale de Mérat*. By treating a portion of the sample of the sugar alluded to with boiling alcohol at 90 per cent, there was left undissolved a substance which, on further investigation, was found to possess all the physical and chemical properties of milk sugar. A careful quantitative analysis of the sample established the fact that it contains 55 per cent of cane sugar and 45 per cent of milk sugar. This latter variety was also found to exist in the ripe fruit of the same tree recently brought from Egypt and analysed by the author.

As a reagent for alcohol, Dr. Berthelot recommends benzoic chloride. When this compound is put into contact with water it is only very slowly decomposed, but if the water contains any alcohol (even as little as 1 in 1000 parts of water) benzoic ether is at once formed; this ether is set free by a single drop of aqueous solution of caustic potassa, the odour of the ether being very peculiar and prominent.

From a lengthy memoir on the nature of the sea-water along the coast of Bohuslän (Sweden) by Professor J. L. Ekman, we quote the most interesting point—viz., that, as regards the quantity of salt contained in the sea-water on the west coast of Sweden, there is greater difference than for any other now known sea. The coast alluded to is, on the one hand, washed by the North Sea, and on the other by the Baltic. In the more northerly part the water at the surface contains rather less than 2 per cent salt, at 60 feet depth 2·5 per cent, at 90 feet depth 3 per cent; in the more southerly portion the discrepancies are greater, but at 600 feet depth 3·5 per cent salt is met with. The average quantity of salt of the oceans is 3·44 per cent; while in the Atlantic, from the equator to from 55° to 60° N. latitude, the quantity of salt in the surface-water is 3·606 per cent, and at depths of from 500 to 10,000 feet 3·578.

LIGHT.

Conversion of cane sugar in the state of solution into glucose under the influence of light has now been proved by E. M. Raoult. The author placed, on May 10 last, a concentrated solution of sugar in water in glass tubes, and sealed the tubes while boiling; these were placed close to each other in the same locality and under identically the same conditions, with the exception that one of the tubes was kept completely in the dark, the other tube being exposed to bright daylight. On October 20 the tubes were opened, and the contents examined. The solutions were perfectly clear, and did not, on being microscopically examined, exhibit the least trace of vegetable matter. The fluid in the tube exposed to light yielded an abundant red-coloured precipitate with the cupro-potassic reagent, thereby indicating the presence of glucose, while the contents of the tube kept in complete darkness did not manifest that reaction at all.

The difficulty of obtaining large specula for telescopes, together with the disadvantages attending the weight, the brittleness, and liability to oxidation, of the speculum metal generally used, has induced Mr. Nasmyth to turn his attention to the employment of silvered plate glass for telescopic purposes, as it possesses perfect truth of surface, is lighter than metal, is not liable to oxidation, and a greater quantity of light is reflected from it than from any metallic surface. To give a concave or convex form to a disc of plate glass, a certain pressure must be made to act equally over the surface. This equal pressure is obtained on Mr. Nasmyth's plan by taking advantage of the weight of the atmosphere. A disk of silvered plate glass, 39 inches in diameter, and 3-16ths of an inch in thickness, is fitted and cemented into a shallow cast-iron dish, turned true on its face so as to render the chamber behind the glass perfectly air-tight; by means of a tube communicating with this chamber, any portion of air can be withdrawn or injected. To produce a concave mirror so slight a power is required, that, on applying the mouth to the tube and exhausting the chamber, the weight of the atmosphere, which amounts in this case to 3558 pounds, acting with equal pressure over a surface of 1186 square inches, causes the glass to assume a concavity of nearly three-quarters of an inch, which, in a diameter of 39 inches, is far beyond what would ever be required for telescopic purposes. On re-admitting the air, the glass immediately recovers its plane surface, and on forcing in air with the power of the lungs, it assumes a degree of convexity nearly equal to its former concavity. The degree of concavity or convexity may be regulated to the greatest nicety, and it is proposed to render the degree of concavity constant by placing in the air-tight chamber a disk of iron turned to the required form, and allowing the pressure of the atmosphere to retain the glass in the form given to it by its close contact with the iron disk. The curve naturally taken by the glass when under the pressure of the atmosphere, is believed by Mr. Nasmyth to be the catenary, inasmuch as its section would be the same as that of a line suspended from each end, and loaded equally throughout its length.

From America we hear of an ingenious application of photography as an aid to locksmiths. Several of the leading railway lines in America have already become bonded carriers, and are engaged in the transportation of imported goods from New York to the interior, under custom-house seal. The peculiar seal used for this purpose shows the practical value of photography to the industrial arts. The photographer for the Treasury Department is now engaged in preparing the seals for the new locks, to be used by that department in the transportation of merchandise in bond, and in such other cases where the protection they afford will be necessary. The lock itself is nothing more than an ordinary padlock, which is provided with an arrangement by which a small piece of glass an inch square is passed over the key-hole and held in place by a small spring, which cannot be reached without breaking the glass itself. By no possible exercise of ingenuity can the lock be picked or opened without breaking this piece of glass. Here comes in the value of photography. A large sheet of glass, red on one side, is prepared in New York, by marking it off into squares of the proper size. On each square is marked a number in figures and irregular spots in red, the rest of the red surface being cut away with hydrofluoric acid. One of these sheets cannot be duplicated. The Government photographer receives them at Washington, and makes three photographs of them, which give perfect *fac similes* of the figures and spots on the glass, and then both glass and photographs are cut into small squares corresponding to each other and packed in boxes, each square of glass having with it three copies on paper. These are forwarded to the officers who will use them. The officer at New York, for instance, whose duty it is, locks the doors of the car containing bonded goods, places the glass square over the key-hole, and forwards the photograph of the same to the officer at Philadelphia or elsewhere whose duty it is to receive the goods. If on the arrival of the car the lock has been disturbed, the inspector is at once aware of it, and the company transporting is liable in bonds required previously. This is an ingenious and practical application of photography to the mechanical arts, and suggests numerous other applications of the art to the safe keeping of valuables, and even the detection of crime, in interference with property, when the progress made shall have rendered automatic photography practical, which is already possible.

Mr. Joseph Sidebotham has given an account of a microscopical examination he had made of dust blown into a railway carriage in which he was travelling near Birmingham. Having collected a quantity of the dust by spreading a newspaper on one of the seats near the open window of the carriage, Mr. Sidebotham brought his microscope to bear on it, and thus describes the result:—"With two-thirds power the dust showed a large proportion of fragments of iron, and on applying a soft iron needle I found that many of them were highly magnetic. They were mostly long, thin, and straight, the largest being about 0·15 of an inch, and under the power used, had the appearance of a quantity of old nails. I then with a magnet separated the iron from the other particles. The weight altogether of the dust collected was 57 grains, and the proportion of those particles composed wholly or in part of iron was 29 grains, or more than one-half. The iron thus separated consisted chiefly of fused particles of dross or burned iron, like 'clinkers;' they were all more or less covered with spikes and excrescences, some having long tails, like the old 'Prince Rupert's drops;' there were also many small angular particles like cast-iron having crystalline structure. The other portion of the dust consisted largely of cinders, some very bright angular fragments of glass or quartz, a few bits of yellow metal, opaque white and spherical bodies, grains of sand, a few bits of coal, &c. I think it probable that the magnetic strips of iron are laminæ from the rails and tyres of the wheels, and the other iron particles portions of fused metal, either from the coal or from the furnace bars."

Some important experiments have been published by Dr. Budde, from which a new theory of the photographic latent image may be deduced. Chlorine gas is passed into a tube closed at one end, and the gas is confined by a column of oil of vitriol saturated with chlorine. This must be done in comparative darkness. A beam of light is then decomposed by means of a prism, and the several coloured rays of the spectrum are allowed to fall in succession on the tube containing the chlorine, an arrangement having been made by which any alteration in volume that might take place in course of the experiment can be detected and carefully registered. When the red rays fell upon the tube, the effect produced was very slight, the increase in the length of the gas column being only the $\frac{1}{25}$th of an inch. According to the degree of refrangibility by the ray to which the chlorine was subjected, so did its expansion increase, until when under the action of the violet, the effect was at its maximum, the expansion being ten times greater than what was caused by the action of the red rays. What is ascertained from this experiment is, that the expansion of the gas is not due to heat, for were that the case the red rays would have exercised the most powerful action, this point having been further ascertained by delicate thermometers. To further establish the fact that the expansion is due solely to the action of light, and not to a decomposition of the sulphuric acid by the chlorine, there was substituted for this acid, saturated with chlorine, the tetrachloride of carbon, the same result being obtained. The result of the experiment appears to warrant the conclusion that the violet rays of the sunbeam act by decomposing the molecule of the chlorine, setting free the two component atoms of which the molecule is supposed to be built up. The two atoms occupy a greater space when separate than when combined, and are also in a favourable condition for entering into combination.

The estimation of the distance of the fixed stars has hitherto baffled the skill of the astronomer. Mr. Fox Talbot has proposed the following manner of effecting this object. Suppose the plane of the orbit of a binary system to pass through the sun, *i.e.*, that the observer is in the plane of the orbit, and that in the spectra of the individual stars there are lines belonging to the same element. The spectra of the two stars, taken through the same slit, should be observed and compared. When the stars appear in the same straight line, it is clear that their velocities relative to the earth are the same, since both are moving perpendicularly to the line of vision; the lines from the two stars will therefore coincide. But when their apparent distance from each other is greatest, the difference of their velocities relative to the observer is equal to the velocity of either star, in its velocity in its orbit about the other. This difference of relative velocity will produce a displacement of the lines, which displacement may be observed and even measured. This gives the value of that velocity; but we know also the periodic time. We have, then, at once the circumference, and thence the diameter of the orbit. We know the greatest angular distance between the stars; we have, then, the distance of the stars from the earth.

M. Papafy has devised a series of sky-rockets adapted for telegraphic service at night for armies when in the field, so arranged that each rocket is, by a variation of coloured light, capable of transmitting six words, visible at a distance of twenty English miles. These signals can be readily kept unintelligible to the enemy, while everything relating to military and strategical matters can be easily expressed. The Prussian War Department has bought the secret of this invention from the author, a Hungarian in service as captain in the United States Army.

W. Müller and Dr. F. Knapp have published a very exhaustive memoir on that kind of glass which owes its beautifully red-purplish colour to gold. The first portion of this monograph contains a review of the literature of the subject alluded to, and of the various theories and opinions held on the condition of the gold while acting as a pigmentary or staining matter. It appears that the quantity of gold required to impart colour to the glass mass is very small indeed, since 1 part of gold in 100,000 of the metal (as the molten glass mass is technically called) distinctly yields a rose-red colour. The authors did not succeed in discovering by experiments what the condition is of the gold in the glass; the chief reason of this failure is that the quantity of gold is almost infinitesimally small.

At last there appears more than a probability that the oxyhydrogen light may be employed with financial success. The experiments recently instituted at the Crystal Palace at Sydenham with M. Tessie du Motay's apparatus are in every way satisfactory—that is, scientifically, for the statements as to economy must at present be based only upon calculation. The apparatus employed is extremely simple and may be described as follows:—A small one-cylinder engine drives a set of three small air-pumps at a rapid rate; these pump air into two retorts built up in a furnace, the external walls of which are about 10 feet long by 6 feet by 6 feet in section. These retorts are charged with manganite of soda, mixed with some oxide of copper. The manganite has a great affinity for oxygen and takes a large percentage out of the air, leaving the nitrogen to escape by small iron pipes. The manganite is thus saturated with the oxygen, which is carried over into a reservoir by a blast of superheated steam, the manganite remaining free to again absorb oxygen. In the reservoir the steam condenses into water, leaving the reservoir filled with oxygen. By means of the alternation afforded by the two retorts the process becomes continuous, and as fast as the air is pumped in so the oxygen is regularly given off. In this way 1 cubic foot of oxygen is the product of 20 cubic feet of air and 15 of steam. The burner is in shape like a double ordinary burner with one tap for the oxygen and one for the hydrogen. The top of the burner is dished out into a hemispherical cavity, in the centre of which is the oxygen hole, and surrounding it some eight or ten smaller holes for the hydrogen. There is thus obtained a solid cone of light. The equivalent of 5 cubic feet of ordinary gas burnt in the usual manner is, in the new light, 1 cubic foot of the same coal gas with about $\frac{5}{8}$ths of a cubic foot of oxygen. At 100 yards from the candelabra of twenty lights in the centre transept of the Palace small handwriting can be easily read.

Mr. John Browning has favoured us with a record of the steps he has taken towards the introduction of compound prisms. In 1864 he made for Mr. Gassiot a very powerful battery of bisulphide of carbon prisms. Instead of the sides of these prisms being made of plane and parallel glass, crown glass prisms were cemented on to them in the manner shown in the diagram (Fig. 9), where A represents the fluid prism and B B the crown-glass prisms added on either side. In a paper read before the Royal Society by Mr. Gassiot, April 7th, 1864, he says:—"In place of giving to the fluid prisms two pairs of parallel sides, advantage has been taken by Mr. Browning of the difference between the refractive and dispersive properties of crown glass, having a refracting angle of 6°, these have been substituted for one of the outer plates of each prism, the bases of these crown glass prisms being brought to correspond with the apex of the fluid prism. By this means the angle of minimum deviation of the prisms is so much altered that eleven prisms can be used instead of eight. An increase of dispersive power, due to refracting angles of 150° of the bisulphide of carbon, is thus gained, minus only the small amount of dispersion counteracted by the dispersive power of the crown glass prisms in the contrary direction." In July, 1869, at the suggestion of Dr. Robinson, of Armagh, Mr. Browning made a large dense glass prism of 60° into a compound prism, the refracting angle of the dense prism being altered to 90°. He has also made several compound prisms of very dense flint glass and light crown glass for the present Earl of Rosse. These compound prisms are more expensive than ordinary prisms, even allowing for the extra dispersive power obtained, and in consequence of the minimum angle of deviation of compound prisms being greater, and their length greater, the size of spectroscopes has also to be increased, and thus will be rendered more cumbersome. A smaller number of compound prisms will produce a given amount of dispersion; but the number of prisms to be made is, under the most favourable circumstances three instead of two; and in the case of a circular battery the smaller number of prisms will occupy a larger circle. The number of plane faces is also greater for a given amount of dispersion, the practical difficulties in securing accuracy not being diminished by the fact that four faces out of the six in a compound prism are connected together. On the score of saving light, such prisms possess undoubtedly some advantage. Mr. Browning has made for Mr. Rutherford, of New York, a compound prism of glass, on a plan which seems to possess some advantages over any hitherto used. The diagram (Fig. 10) represents this prism. In this diagram the two darkly shaded prisms are of dense flint of 90°, while the three other prisms are of crown. Such a prism is very nearly equal in dispersive power to three ordinary flint glass prisms of 60°. There is no loss of light at the two intermediate surfaces, and it is much more compact. Experiment has proved that the angles of the flint glass prisms in this arrangement cannot with advantage be made more than 90°, nor the outside crown glass prisms less than 30°.

FIG. 9.

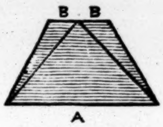
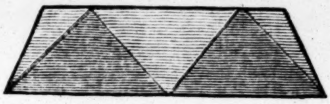


FIG. 10.



MICROSCOPY.—A microscope lamp, combining most of the advantages of existing ones, has been contrived by a committee of the South London Microscopical and Natural History Club, for use at its meetings. It is mounted on a stand supported on a solid ring, after the retort stand model, which experience has proved to be less liable to overturn than any other. The lamp revolves in its socket, so that either the edge or the flat side of the flame can be used at pleasure. Hailes's porcelain shade has been adopted, which has the double advantage of protecting the eyes from the glare of the lamp as effectively as a metal chimney without its disagreeable heat, and affording an easy means of obtaining white cloud illumination. The burner is a small one of the best American manufacture; and all the parts are so simplified that the lamp can be supplied at a lower cost than the majority of microscope lamps, which it quite equals for all practical purposes.

Some microscope lamps have lately been constructed in which benzoline is employed as fuel. This liquid possesses the advantage of being much cleaner in use than paraffine, the leakage of which very penetrating fluid is always a source of annoyance to those microscopists who have to carry a lamp from place to place. The lamps are very small and compact, and are well adapted for illuminating the achromatic condenser directly without using the mirror, a mode of lighting preferred by many of our best observers. There is no doubt that when the burner is properly adapted for the consumption of benzoline, a light approaching in intensity and whiteness that of camphine may be expected. In the few experimental lamps at present made, burners like those for the combustion of paraffine have been used, and consequently the quality of the light is much inferior to that which the fuel is capable of yielding. A lamp giving a very small intense flame and requiring but little attention is a desideratum. The camphine lamp is perfection in every respect, but the care required to keep it in order is an impediment to its very extensive use.

Dr. J. J. Woodward has succeeded in producing some fine photographs of histological preparations by means of sunlight. Hitherto preparations of this kind, stained and injected, have yielded very inferior impressions by daylight, illumination with the lime, magnesium, or electric lights having given better results. The light enters the dark room through an achromatic lens of 2 inches diameter and about 10 inches focus, instead of the usual aperture, and is received upon the achromatic condenser after diverging from the focus. This illumination appears to have remedied the inconvenience caused by diffraction and interference, which in former experiments caused great confusion in the image. The low powers used in photographing these preparations giving in most instances an almost instantaneous picture, Dr. Woodward has contrived a means of regulating the exposure by a simple mechanical contrivance, and for these rapid impressions has managed to dispense with the use of the heliostat. A series of nine photographs, illustrating the capabilities of the process, has been placed in the collection of the Royal Microscopical Society.

Mr. H. J. Slack has continued his observations on deceptive appearances presented by objects under the microscope. Some specimens of fine ruling on glass and steel by Mr. J. F. Stanistreet, F.R.A.S., executed by a simple machine* of his own contrivance, have furnished some singular results, which, as in former cases, point to the necessity of using the greatest caution in interpreting the results of observations on unknown substances. The objects supplied by Mr. Stanistreet consist of stars composed of bands of fine parallel lines, intersecting each other as they approach the centre, and so forming a central star. When examined on a dark ground with powers of 3 inches to ⅔ inch, the idea of the rays standing up obliquely from the plane of the glass like the rays of a fan is suggested, the apparent slope being varied as the stage with the object is caused to revolve. Under a slight variation of the lighting, the inner star caused by the intersection of the bands can be made to appear in a higher plane than that of the primary star. The circular unengraved space in the centre has the appearance of a deep hole; as in former instances, the eye is perfectly satisfied with the focussing, which gives the appearance of the lines being in different planes. In another star composed of radial lines, those most brilliantly illuminated appear to stand above the rest. Complicated patterns, in which the intersections are more numerous, viewed with a ⅔ inch and Beck's vertical illuminator, give at the most satisfactory focus the appearance of solid threads to the lines, one under the other at the simple intersections, and a tendency to make the spots of complicated intersection appear higher than the rest. With a one-fifth and Powell and Lealand's modification of Professor H. L. Smith's vertical illuminator, the complex portions of the pattern are resolved, but with a decided suggestion that the cuts are elevations or threads laid upon a semi-transparent surface like white porcelain.

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* Mr. Stanistreet's ruling machine is described and figured in the Monthly Microscopical Journal for December, 1871.

Captain F. H. Lang and Mr. Tatem, of Reading, give a mode of re-mounting or selecting diatoms from slides already mounted in balsam. The balsam-mounted slide is placed upon a hot plate, and when sufficiently heated, the cover is removed by means of a needle. The diatoms will either be on the slide or the cover, according to the mode adopted in mounting. Apply at once while upon the hot plate a drop of turpentine, remove the slide to the stage of the dissecting microscope, and add more turpentine. Have ready a clean slip of glass, on which has been placed a drop of turpentine. In the case of large discoid and other forms, having applied plenty of turpentine, they can easily be transferred by means of a fine sable-hair brush from the original slide to the pool of turpentine on the clean one. In the case of the finer forms, it is better to place less turpentine on the original slide, collect the diatoms into a heap, allow the turpentine to dry a little, and then by a twist of the brush to transfer them *en masse* to the new slide. In either case, having got them there, push them together and mop up the superfluous turpentine, and then, still under the dissecting microscope, slant the slide by placing a piece of folded paper under one end, and apply a little benzole by means of a clean brush or glass rod, immediately above them, that is, on the end of the slide that is raised, and allow it to float gradually over them, care being taken that it does not flow with too great a rush and carry away the diatoms with it. Repeat this process some half-dozen times, till the whole of the turpentine and balsam has been washed away, and till the valves are left dry and black after the benzole is evaporated. They can then be transferred in the usual way to any other slide.* If gum has been used to fix the diatoms, it may be found that some of the valves, especially the discoid ones, remain obstinately adherent to the glass after the turpentine has been placed over them. In such a case the process as above detailed must be carried out on the original slide, and then, after the benzole is thoroughly evaporated, water must be applied two or three times in the same way as the benzole, for the purpose of washing away the gum and freeing the diatoms, which can then, when dried, be lifted one by one and transferred in the usual manner. By this simple and easy mothod, selections can be made from balsam-mounted slides of any particular valves required, and spoilt and unsatisfactory mounts re-set.†

Mr. Browning has prepared four series of objects for the micro-spectroscope. The first three consist of fluids in sealed tubes; one set of twelve being devoted to chemical solutions; the second, a similar number of colouring matters from vegetable sources, and the third set of six illustrates blood compounds. The remaining collection consists of various blowpipe beads and crystals. They are accompanied by a catalogue giving brief directions for viewing them, and also a short explanation of the use of the various micro-spectroscope apparatus constructed by Mr. Browning. In the absence of a manual on the use of this important addition to the microscope, the specimens and directions will be of great service to those commencing such studies. It is much to be desired that some competent person would undertake a practical work on the micro-spectroscope, as nearly all the information at present published is contained in various scattered papers.

"The Monthly Microscopical Journal" for September contains a paper by Mr. H. C. Sorby, on "The Examination of Mixed Colouring Matters with the Spectrum-Microscope." It forms a valuable sequel to many other contributions to a knowledge of the spectra of vegetable colours by the same author, and consists chiefly of observations on various *Algæ*. The subject is too elaborate to admit of an abstract. In the same Journal is also "An Account of the Spectra formed by the Passage of Polarised Light through Doubly Refracting Crystals seen with the Microscope," by Francis Deas, M.A., LL.B., F.R.S.E.

Mr. H. G. Bridge communicates to the "Monthly Microscopical Journal" for November some remarks on the mode of mapping spectra with the "Bright Line Micrometer," adapted by Mr. Browning to the micro-spectroscope. The paper is accompanied with a plate containing twenty-two figures, drawn to scale, of the spectra of various coloured fluids, &c., compared with the lines of the solar spectrum.

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* Quarterly Journal of Science, vol. i. (N.S.), p. 276.

† Monthly Microscopical Journal, vol. vi., p. 217.

Microscopists who are in the habit of making drawings with the aid of a ruled disc in the eye-piece,[*] will find the "sectional paper" of Messrs. Letts convenient for recording their observations. This paper is ruled in squares of twelve different sizes, varying from $\frac{1}{12}$ inch to 1 inch. The lines are of a very pale-grey colour, so as to be just visible, and scarcely interfere with the finished drawing, while they are sufficiently plain to guide the artist in copying from the ruled field of the microscope.

A simple and efficient erector, for use with the compound microscope in dissection and other manipulations, has been contrived by Mr. E. Richards, F.R.M.S. It consists of a glass mirror platinised on the front surface placed over the eye-piece at an angle of 45°. The microscope is used in a vertical position, which allows vessels of fluid to be placed on the stage, while the observer looks forward at the reflected image. The reflection being from the front surface, the confusion occasioned by the double image of an ordinary mirror is avoided; the platinum surface retains its brilliancy for a longer period than one of silver, and the definition is extremely perfect.

HEAT.

Captain J. Ericsson has constructed an apparatus for measuring the radiant intensity transmitted by flames, to endeavour to prove that the radiant power of flames is not less than that of incandescent solid substances. The measurement of the radiant heat transmitted by flames is of great importance, as it furnishes a means of measuring with precision temperatures which cannot be ascertained by direct contact. The construction of the apparatus is based upon the law that the intensities of circular radiators of different size, imparting equal temperature at equal distance from the radiating surface, are inversely as the squares of the sines of half of the subtended angles, that is, the angles formed by the axes of the circular radiant surface and the heat rays projected from the circumference to the substance receiving the radiant heat, in the prolongation of the axes. It is thus possible to determine the temperature of a circular radiator without knowing its size and distance. A perforated diaphragm of polished silver is so arranged before a thermometer that the circumference of the perforation may form a known angle with the centre of the bulb of the thermometer. The metal cone containing the thermometer and diaphragm is surrounded with a water-jacket. Suppose the thermometer to indicate 282°, and the temperature of the surrounding water to be 73°, then according to the law laid down, if the angle subtended by the centre line of the conical vessel and lines drawn from the circumference of the flame-disc to the bulb of the thermometer be 16° 8′, we know that its temperature must be 12·91 times greater than that of the flame, or 2698° F. ($282 - 73 = 209$; $209 \times 12{\cdot}91 = 2698$). Captain Ericsson promises a full extension of the application.

A simple apparatus for the observance of some beautiful phenomena connected with the vibrations of flames, &c., can be constructed as follows:—A disk of white cardboard, with apertures oblong in radial direction, is set on a spindle, so as to be rotated at any requisite speed. To examine, for instance, the flame of a gas light (in a glass tube, to prevent disturbance by air currents), place the disk in front of the light, so that the eye can see the light through each slit as it comes to a vertical position. If the speed of the disk's rotation is such that the interval of time between two slits passing the eye is just equal to the period of a vibration of the flame, the flame appears to be motionless; but if the velocity be reduced, the flame is seen to go slowly through its changes of form. If the interval be equal to, or one-half of, or one-third of the period of the vibration of the light, the illusory appearance of a disk having as many, or twice, or three times the number of slits really in the disk is seen. This phantom disk will appear to be motionless when the periods coincide; but when otherwise, it revolves in one direction or the other. It is obvious that the vibrations of the flame can be easily counted by this means. The inventor, Mr. Charles J. Watson, counted, with a sixteen-inch tube, 453 vibrations of the flame per second. By this instrument the undulation of the vibrations of a wire can be seen to travel up and down the wire; and if watched by both eyes through the slits, the spiral course of the undulations can be observed.

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[*] Chemical News, vol. xxi., p. 30.

F. Tommassi has described a series of experiments, illustrated by woodcuts, for the purpose of proving the possibility of converting into dynamical work the dilatation produced in liquids by heat; he proposes to utilise this motive force for the purpose of working hydraulic presses.

A new application of the oxyhydrogen light to the separation of metals has been patented by Tessie du Motay. It is especially applied to the metallurgy of copper. The usual treatment of copper has had until now for its object the extraction of the metal of a certain class of ores, where it is found combined with sulphur, arsenic, antimony, tin, lead, iron, &c. According to the new method the metal is first smelted with a flux of silicates; metallic silicates are formed, in which the sulphur and arsenic are eliminated and replaced by silicic acid. These metallic silicates are then further treated in a blast furnace, and submitted to the reducing property of incandescent charcoal; the metallic oxides are reduced in a metallic state and fused, and thus collected in ingots. The ingot thus obtained is composed of a variety of metals from which the copper has to be separated; this object is attained by smelting these ingots in a reverberatory furnace in the presence of atmospheric air, which oxidises all the metals except the copper; it is by this process of cupellation that M. Tessie du Motay utilises the slowly oxidising property of the oxyhydrogen flame, in order to facilitate the separation of the copper; he directs the flame, obtained by burning a mixture of common street gas and oxygen gas, on to the fused mass. The combustion of this gaseous mixture furnishes a certain amount of carbonic acid and oxide of carbon, as well as a small proportion of water; it is this water, claims the inventor, which, at the high temperature to which it is submitted, has the property of oxidising rapidly all the metals except the copper and lead. The fused metal obtained is then pure copper, if the original ingot contained no lead; and is composed of an alloy of copper and lead, if the ingot contained these two metals.

Dr. A. Vogel records a series of experiments made to prove the well-known fact that sulphuric acid is a constant product of the combustion of coal-gas, even when purified as perfectly as possible from sulphuretted hydrogen; the source whence the sulphuric acid is derived is the sulphide of carbon present in the gas.

The apparent volatilisation of silicium and boron has been observed by L. Troost and P. Hautefeuille. They describe a series of experiments made with pure silicium and boron, each by itself, placed in porcelain tubes, kept at a very high temperature in a slow current of dry and pure hydrogen gas, and the reaction which ensues by the admission into the tube of fluoride of silicium, chloride of silicium, and fluoride of boron. Silicium is under these conditions apparently volatilised, forming a brown-coloured smoke, which, in a cooler part of the tube, is condensed sometimes as amorphous silicium, sometimes deposited in crystalline state. The same obtains with boron, but this apparent volatilisation is due to a simple mechanical effect, conjointly with the existence of compounds of silicium with chlorine and fluorine, which are only formed at a very high temperature, and dissociated at red heat.

We extract the following graphic description of the action of cold on vapours from the "Chemical History of the Creation," by J. Phinn, Editor of the New York "Technologist." The book is full of similar striking illustrations, and the subject is treated in a manner which makes it peculiarly interesting to scientific men:—"It is a generally received opinion that all gases are merely vapours of liquids that boil at a very low temperatures. Thus, while water boils at 212°, common ether boils at 96°, and sulphurous acid at 0°. Consequently, while water is always a solid or a liquid in all parts of the earth, ether would be a permanent gas in any place where the highest tropical temperature prevailed, and sulphurous acid is always a gas except in the cold of the polar regions. Even the dense and brilliant metal mercury, when exposed to a temperature sufficiently high, becomes, in reality, a perfectly colourless and transparent gas, and carbonic acid gas, when exposed to a temperature sufficiently low, becomes first a yellowish, oily-looking liquid, and then a beautiful snow-white solid. The only difference, then, between common snow and carbonic acid snow is, that the one is much colder than the other, while, on the other hand, the only difference between carbonic acid gas and mercury gas is, that the one requires a higher temperature for its existence than the other. There are certain gases, however, which no degree of cold yet reached has reduced to the liquid, far less to the solid form. Prominent among these are oxygen and hydrogen—the two gases that when combined form water. But, after it had been observed that intense cold tended to reduce all gases and vapours to the liquid form, it was supposed that, if hydrogen and oxygen could only be made cold enough, they would become liquid too. So they were cooled with freezing mixtures, but still they remained in the gaseous state. Then a still more powerful freezing agent (solid carbonic acid) was used. But, although mercury became solid, and alcohol, unless very pure, became thick and pasty, instead of clear and limpid, still hydrogen remained unaltered. After a time a still more powerful freezing agent (liquefied laughing-gas) was discovered. Natterer, of Vienna, made a powerful steel pump and pumped laughing-gas into a large iron receiver or bottle until it became liquefied with the pressure. When a little of this liquid was poured into the air it evaporated and produced the greatest degree of cold ever observed—a degree of cold 257° below the zero of Fahrenheit's thermometer. Of such a temperature we have but a very faint idea. Let us begin at the temperature of our own bodies, and gradually descending by well-known stages, see if we can realise the fearful degree of cold that is expressed by 257° below zero. Human existence requires a temperature in the neighbourhood of 100°—a temperature which, under ordinary circumstances, is easily maintained by the chemical and vital actions going on in the system, whenever the external atmosphere does not sink below 60°. When the temperature of the surrounding air falls below 60°, the animal carries on a continual fight for the maintenence of its normal temperature. At 32° the contest becomes more energetic. Warm clothing is called into requisition, and, if the air should be agitated by keen winds, the clothing must be warm and the fuel (food) liberal, or the animal will suffer. When the temperature sinks to zero, even on a clear, still day, there are few persons that do not feel it keenly, and, if any wind should be stirring, ugh! how cold it is! But, keenly though we feel it, we have just begun to descend the scale. Let us take a leap down to −40°. The mercury in our thermometers will now congeal, and, if we find it necessary to expose ourselves, we must encase our persons in triple layers of fur. Let us take another leap of equal magnitude, and descend to −80°. This is lower than any natural temperature ever observed, and it is improbable that human life could be long sustained in an atmosphere cooled to this degree. At six degrees below this point, carbonic acid condenses to a liquid, and the breath of our nostrils would condense as it issued forth, and would fall to the ground in streams. Forty-four degrees below this point carries us to −130°. If such a temperature could be produced over a large area, what strange phenomena would present themselves! The air would be dry—drier than the summer dust—for all moisture would have been precipitated from it long ere this temperature had been reached. No animal could breathe such air, and if plants could live and perform their functions at such a low temperature, they could find no sustenance in an atmosphere as cold as this, for all the carbonic acid would descend to the earth as beautiful white snow. The breath from the nostrils of every animal, provided animals could exist, would yield a shower of these flakes, and the air would be entirely purified from the products of respiration. And yet we are not half way down to the point reached by Natterer.

He went twice as far, and, even then, oxygen and hydrogen did not liquefy, but maintained their condition as clear and beautiful gases."

ELECTRICITY.

M. Ruhmkorff in continuing his many experiments on electro-magnetic induction has met with some results which he considers worthy of publication. When a bundle of iron wires is taken and covered with a very thin copper wire destined to convey an intermittent current from a pile, and when on this is wound another thin wire to obtain the induced current, if the latter is wound on the centre of the bundle where no magnetism is manifested, there is obtained an induced current of an intensity more than double that which the same quantity of fine wire wound on one of the extremities would give. M. Ruhmkorff then constructed an induction coil with an annular core, but only obtained a spark of 2·5 m.m. in length. He then cut the ring, when the spark increased to a length of 5 m.m. Finally, a piece of wood of 5 m.m. in breadth was inserted between the severed ends of the annular core, when the spark increased to 15 m.m. In doubling the thickness of the piece of wood, the result remained the same.

M. Th. du Moncel has lately submitted to the Academy of Sciences of Paris some results of a series of interesting and valuable experiments on the size of the plates of a voltaic couple, relatively to each other, producing the best working current. The experiments and the deductions have a great practical bearing. The experiments were made with two Bunsen elements. In the one the negative electrode was constituted of two plates of carbon plunged into nitric acid in the exterior cup; the positive electrode, a single plate of amalgamated zinc was plunged into the porous cup containing acidulated water. In the other element two plates of zinc, united at the bottom, replaced the two plates of carbon of the first element, while a plate of carbon took the place of the zinc. The liquids were the same, and the vases exactly equal in height. The plates were freshly amalgamated. The plate of zinc of the first element had a submerged surface of 224 square centimetres. The second pile, an active surface of zinc of 544 square centimetres. The surfaces of the carbons were of corresponding size. The intensities of the currents produced were read off from a tangent galvanometer with a ring formed by a copper wire 0·7 m.m. in diameter, and 1·32 metres in length. The pile with the greatest amount of surface of zinc gave a deflection of 78° 5′; the pile with a small surface of zinc, 84° 10′. The temperature of the exciting liquids was—for the first pile, 29·8°; for the second, 30·2°. The weight of zinc dissolved in the first pile was 32 grammes; in the second, 38 grammes. One of the results would appear to be that the consumption of zinc with regard to the amount of work done is nearly the same in both cases. Therefore, in a pile where the current is constantly in circulation, there is the advantage in the point of view of economy of expenditure of zinc in the employment of positive electrodes of small surface. The experiments also prove that the current gains in intensity when the positive electrode is smaller than the negative electrode. These experiments accord with those of M. Delaurier, who found that a plate of zinc of 9 m.m. in size, furnished at an expense of 115 grammes a deposit of copper of 101 grammes in 48 hours, while a surface of zinc ten times as large would only furnish a continued action for one hour with a work represented by a deposit of 5 grammes. The liquids were completely exhausted. A similar observation has also been made by M. Ruhmkorff, who found that if the zinc plate of a bichromate of potassa pile were plunged to one-fifth of its height in the exciting liquid, the couple preserved during six hours an intensity that corresponded with that obtained from the total immersion of the zinc; and in the latter case, when the entire plate was covered, the current could not maintain a platinum wire at a red-heat for longer than ten minutes. These results are strongly in favour of the use of small surfaces of zinc. In practice, where generally commercially pure zinc is employed, oxidation goes on continually all over the surface of the zinc; economy therefore demands the reduction of the surface.

M. W. Beetz has lately made several determinations of the electro-motive force of various hydro-electric elements, employing a compensating battery and a system which seems capable of great exactitude. A Bunsen's element he considers to give an electro-motive force = 1·799, a Grove's element = 1·684, and a Leclanché = 1·167 times that of a Daniell's standard cell.

A printing telegraph for private wires, patented in America about a year ago by Messrs. Pope and Edison, has lately been brought under the notice of the English public. It is well adapted for private wires and for railway telegraphs, being simple and durable in construction, and capable of being understood and operated without difficulty by persons having no special knowledge of telegraphy. The instrument operates upon what is known as the "open circuit" principle, each station transmitting with its own battery—the line at the receiving station being connected directly through the relay to the earth, without the intervention of a second battery. The printing apparatus is placed upon a circular iron base in the centre of the table. In front of it is placed a dial, containing the letters of the alphabet, arranged in a circle, and provided with an index or pointer, mounted upon a horizontal shaft. This shaft also carries a type-wheel and a scape-wheel, with racket-shaped teeth, corresponding in number to the characters upon the type-wheel and dial. An electro-magnet beneath the base is provided with an armature, attached to a vibrating lever, the latter armed with pawls or clicks, so arranged in relation to the scape-wheel that every time the electro-magnet attracts its armature the wheel is made to revolve a distance of one tooth, and the type-wheel and index upon the same shaft a distance of one letter. At the extreme right of the circular base, and partly beneath it, is placed a second electro-magnet, whose armature lever passes in a horizontal direction below the type-wheel. Directly underneath the type-wheel an india-rubber pad is fixed upon the lever, by means of which an impression of the letter opposite it upon the type-wheel may be taken, The lever is also provided with a simple mechanical device for moving the paper forward the proper distance, as each successive character is imprinted upon it. The type-wheel is provided with a suitable inking roller. It will thus be understood that the printing mechanism is operated by two distinct electro-magnets, one of which is so arranged that its successive pulsations may be made to advance the index step by step to any required letter, while the other forces the strip of paper against the inked type upon the wheel, after it has been moved to the proper position by the first magnet. These two electro-magnets are placed in the circuit of a local battery, which is brought into action by a relay placed in the main line circuit, as in the ordinary Morse instrument, and is the same in principle, with the addition of a device termed the "polarised switch," which consists of a permanently magnetised steel bar pivotted between the poles of the relay magnet, the polarity of which depends upon the direction of the electrical current in the main circuit. The polarised switch determines the direction of the local current, causing it to pass through the magnet for moving the type-wheel, or through the impression magnet, as may be required. Two lever finger-keys are connected to the poles of the main battery in such a manner that, by depressing the right-hand key, the positive pole of the battery is connected, through the relay magnet to the line, and the negative to the ground, while the left-hand key, on the contrary, sends a negative current through the relay and line in the same manner. By depressing the right-hand key a sufficient number of times in rapid succession, a series of positive currents is sent through the relays at both ends of the line, which series is repeated upon the local circuits of both instruments. The positive currents deflect the polarised switches to the left, so that the local current is directed into the type-wheel magnet. The index and type-wheel of both instruments, therefore, advance one letter every time the key is depressed, and they may thus be readily brought to any desired letter. When this has been done, the left-hand key is depressed, which sends a negative current, reversing the polarised switch, and throwing the local circuit through the printing magnet, producing the impression of the letter upon the strip of paper. The apparatus, it will be seen, is entirely automatic, while it is also very simple and unlikely to get out of order. A battery of two carbon cells per mile will work the instrument.

M. F. M. Raoult has lately submitted to the Academy of Sciences the result of his researches on the calorific coefficient of the hydro-electric and thermo-electric currents. The law he deduces is—that the heat evolved by an electric current is independent of the nature of the galvanic element, the calorific coefficient, K*e*, being the same for all sources of galvanic (current) electricity.

Count du Moncel has recently published, in the "Bulletin de la Société d'Encouragement pour l'Industrie Nationale," an interesting report on the bichromate of potash battery, in which he states the following conclusions:—Of all the galvanic elements used in industry and the arts, those with bichromate of potash yield the greatest electro-motive force, are the most economical, and give off no irritating vapours, but are, on the other hand, not very constant and become strongly polarised. These effects are less marked in the Delaurier element with two liquids, and are also greatly obviated in the Chutaux element with a constant discharge; the use of the Chutaux element with sand and constant discharge offers peculiar advantages in every respect for electric telegraphy and all similar applications, because this element is for equal force more economical than the Daniell element. The Delaurier element with two liquids may be advantageously used instead of the Bunsen element when strong electric currents are required. In order to obtain a continuous and energetic action with the bichromate of potash battery, the most effectual method is the application of a current of air, as invented by M. Grenet. By the addition of bisulphate of mercury to the bichromate solution in the Chutaux element a very continuous and energetic electric current may be obtained.

Dr. Alvergniat has described some new phenomena of phosphorescence produced by frictional electricity. A vacuum is first made in glass tubes about 45 centimetres in length. After the introduction into these tubes of a small quantity of either chloride or bromide of silicium, the pressure inside these tubes having been reduced to 12 or 15 millims., they are sealed before the blowpipe. When such tubes are rubbed with a piece of silk, there appears inside the tubes a bright luminous flash, which exhibits a rose colour with the chloride, and a yellowish-green colour with the bromide, of silicium. Only when a more perfect vacuum is made in these tubes the induction spark produces a luminous phenomenon in them, but then the phosphorescence by friction entirely disappears.

All draughtsmen are acquainted with the simple device of puncturing holes through a drawing for the purpose of obtaining an outline and afterwards transferring the outline by sifting fine plumbago or other powder through the small holes. The fatigue of making the holes by hand is very great, and M. Cauderay, of Lausanne, proposes to employ the induction coil for this purpose. A table covered with tinfoil is connected with the negative pole; on it may be placed as many sheets of paper as the spark will pass through. The positive pole, consisting of a metal bar, insulated with gutta-percha, can serve as a pencil for copying the tracings. The metal point of the pencil being moved about on the contour and outline of the engraving, electric sparks spring across every time a connection is made, and puncture fine holes through the paper. It is said to require little skill to guide the pencil, as the ink tracings being good conductors, carry the pencil easily along. In the case of valuable engravings it is better to make a copy with the pantagraph and use that for the punching process. The pantagraph is connected with the positive pole of the induction apparatus, and it is placed upon a table, one-half of which is covered with tin-foil. The drawing to be copied lies upon the insulated half, and the sheets of paper to be punctured are laid upon the tin-foil. The pointer of the pantagraph moves around the outlines of the engraving, and between the pen and the foil the sparks pass to pierce the paper upon which the outline is to be made. In this way the engraving or original drawing is in no way injured.

S. H. Lockett, Professor of Engineering at Louisiana University, writing from Niagara Falls, relates the following phenomenon:—"While crossing the upper or new suspension bridge to-day, I had occasion, while conversing with a friend, to point toward the falls with my walking-cane. As soon as I did so, I heard distinctly at the end of my cane a buzzing noise, like that made by electricity passing from a heavily charged battery to a sharp-pointed rod. Repeating the experiment, the same noise was heard. I stopped several passers, and tried their canes with the same result, except in one case where there was no ferule on the cane. I immediately supposed this might be an electrical phenomenon, and set to work to test the correctness of my supposition. I took a key, and held it at arm's length toward the falls, and heard the same sound. Finally, at dark, I returned to the bridge, and pointed my cane in the air, and had the satisfaction of seeing a clear beautiful electric brush on its end. The best point to observe this interesting and beautiful phenomenon is in the middle of the bridge, and the cane must be held at arm's length, so that its end may be at some distance from any part of the bridge. The success of the experiment seems to depend a good deal on the direction of the wind and the amount of vapour blown over the bridge. To-day the wind is strong, and drives the mist directly from the falls to the bridge, but an occasional shifting or lulling of the wind would cause a cessation of the electrical noise or light. My explanation of the phenomenon is this:—As Franklin with his kite and key caught the lightning from the clouds of heaven, so here, from the suspension bridge, surrounded by vapours from the mighty falls, we may stand and gather on our walking-canes the electricity generated by the falling waters and contained in the floating mists. I think suitable arrangements might be made to collect enormous quantities of electricity from these mists, which might be used in producing grand and striking effects, thus adding another attractive feature to the sights at this wonderful place."

The duration of the spark of the Leyden jar has been measured by Professor Rood by an ingenious apparatus, by which intervals of time, measured by *billionths of a second*, are estimated. The wheel, painted black and carrying a distinct white point on its circumference, is provided with some means of giving it a uniform motion of rotation. If the wheel makes one revolution in one-sixth of a second, the white point will appear as a continuous circle; for any impression produced on the eye remains during one-sixth of a second, therefore during one revolution of the wheel all the successive positions on the circumference occupied by the bright point remain impressed on the eye, and hence the circle appears unbroken. Now, if a flash of light in the place of the white point should last one-sixth of a second, the circle would appear complete; but if it lasted one-twelfth or one twenty-fourth of a second, then would the point describe one-half or one-quarter of the whole circle. Thus, by this simple means—remembering that the smaller the arc of the circle, the less the duration of the flash—we can readily measure from the length of this arc very minute portions of time. If, instead of having one white point on the wheel, we have 100 or more radial white bands drawn with the space between them equal to their breadth, then, if the wheel makes ten turns in a second, any radial white band will advance into the position previously occupied by an adjoining black band in one-thousandth of a second, and if the flash of light lasted one-thousandth of a second, all the white bands would, during that interval, have advanced into the position of the black bands, and *vice versa*, and the disk would appear without bands and covered with a uniform grey tint. We can thus readily and accurately measure one-thousandth of a second. With the above apparatus Arago about the year 1835, first showed that a flash of lightning lasted less than one-thousandth of a second, but did not succeed in fixing the minimum limit to its duration. Professor Rood, however, was more fortunate; for during the well-remembered remarkable display of lightning in August, 1869, with an apparatus similar to the above (extemporised from a piece of pasteboard and a shawl pin), he succeeded in measuring one five-hundredth of a second as the duration of those vivid and extensive flashes. It was soon found that the velocity of the revolving disk fell far behind that of the spark of the Leyden jar, for its flash showed the revolving radial bars as absolutely at rest as when the disk was stationary. But Professor Wheatstone, in 1834, substituted for the revolving disk a mirror turning on a horizontal axis, and instead of the white point or bars he used the image of the spark reflected from the turning mirror. If the spark be instantaneous, then will it appear in the rotating mirror just as it is seen when reflected from the mirror at rest; but if the spark last during even an extremely minute fraction of a second, it will appear drawn into a line in the direction in which the mirror turns. Wheatstone thus measured the one million one hundred and fifty thousandth of a second, and ascertained that the electricity from a Leyden jar goes over a copper wire at the rate of 288,000 miles in a second, exceeding light itself in velocity. Professor Rood has now combined the two methods above given by viewing the appearance of stationary parallel and equidistant white and black bands reflected from the revolving mirror while the flash of the Leyden jar illuminated them. The direction of rotation of the mirror being across the length of the bands (which were only sixteen-thousandths of an inch apart), if the flash lasted during the time for the turning mirror to reflect a black band into the adjacent white space, then the bands would entirely disappear, and the plate on which they were drawn would appear of a uniform grey tint. By knowing the number of turns the mirror makes in a second, and the number of bands in the space of one inch, it is easy to calculate the time necessary for the obliteration of the bands. Thus has he produced, by this simple combination, an instrument surpassing in minuteness and accuracy of determination all that has gone before—an accomplishment which cannot but reflect much renown upon American science. He has succeeded (with a mirror making 350 turns in a second) in measuring accurately *forty billionths of a second*, and has shown that this is the duration of the flash of a Leyden jar having only 11 square inches of surface and one twenty-fifth of an inch striking distance—an interval of time just sufficient for a ray of light (going at the rate of 190,000 miles in a second) to travel over 40 feet. The flash from a jar having 114 square inches of surface lasted four times as long as the smaller jar. Thus, for the range of electric flashes we have measures from the five-hundredth to the forty-billionth of a second. To enable the mind to form some idea of the minuteness of the spaces of time measured by Professor Rood, we may mention that the forty-billionth of a second bears nearly the same proportion to a second as a second does to a thousand years.

Mr. George Gore, F.R.S., has, in pursuing his researches in thermo-electricity, constructed a liquid thermo-electric battery. This battery is sufficiently powerful to give a deflection of 40° with a Thomson's reflecting galvanometer, having a resistance of 3040·7 British Association units (=77872·327 miles of copper wire 1-16th of an inch in thickness). It consists of twelve glass tubes three-fourths of an inch in diameter and 10 inches in length, one end of each tube containing a platinum wire hermetically fastened. Each tube is bent into the form of the letter J, the lower limb being the open one. The open end is closed by a cork, through which is passed a second platinum wire. The tubes are fixed vertically in a wooden stand. A tin box, the bottom of which has a long semicircular cavity so arranged as to cover the upper parts of the tubes as with a cap, when it is filled with boiling water forms the upper part of the apparatus and is the source of heat. A lamp placed under a projection from one side of the bath maintains the water at the boiling-point. When it is desired to charge the battery, alternate tubes are filled with a previously boiled and cooled mixture of 1 part of sulphuric acid to 76 parts of water. The remaining six tubes are filled with a similarly prepared solution of 110 grains of hydrate of potassium dissolved in 19 ounces of water. The upper and lower wires are then connected to form an electrical series, the platinum wires in the hot acid being the negative, those in the hot alkali the positive elements of the upper ends; and the platinum wires in the cold acid the positive, in the cold alkali the negative elements at the lower ends of the tubes of the battery. The series is thus connected with acid to alkali and alkali to acid. Mr. Gore believes that the electric currents produced by the direct influence of unequal temperature of copper and platinum electrodes, in conducting liquids which do not act chemically upon those metals, have their origin in the temporary changes of cohesion of the layers of metal and liquid which are in immediate and mutual contact, and that these currents may therefore be considered as very delicate tests of the kind and amount of temporary molecular movements produced by small causes.

If a piece of amalgamated zinc is made to touch a piece of platinum in the presence of acidulated water, the well-known extraction of hydrogen bubbles takes place from the latter metal. Whilst trying a series of such experiments, and also some of a similar nature, Professor Thomas Bloxam observed an unequal evolution of bubbles from some parts of the platinum plate, and accordingly submitted the matter to inquiry. The first series of experiments had for their object to ascertain the amount of gas evolved in a given time from a zinc and platinum plate in contact. Expt. 1. A tube graduated to 1 cubic inch was filled with water acidulated with one-sixth of strong sulphuric acid; a strip of platinum as obtained from the apparatus makers was cut 7 in. long, ¼ in. wide, and introduced into the tube, which was then inverted upon a small plate of amalgamated zinc also standing in the same acid and water. The time at starting and at the termination was accurately recorded, as also the temperature and pressure throughout all the experiments. Time resulting from a mean of many experiments was 22 minutes. Expt. 2. The strip cleaned by heating it in oil of vitriol, and thoroughly rinsing in distilled water, gave as a mean result—time 14 minutes. Expt. 3. The strip merely passed through the finger several times. Time 28 minutes. It will be seen from these results that the platinum as it leaves the instrument makers is absolutely, so to speak, chemically dirty; but the mere contact with the hand is sufficient to materially modify the action. The strip cleaned by oil of vitriol was dipped for a moment into solution of common salt, and again tried, when the time required for collecting the cubic inch of hydrogen was nearly doubled. The strip having been made dirty by touching, was ignited in the flame of a good Bunsen lamp for one minute, and then arranged in the cubic inch tube. The time required was 15 minutes, thus showing that it had been in great measure cleaned, though hardly so satisfactorily as in the heating with oil of vitriol. Expt. 4 was devoted to the action of copper negative plates in similar strips to the platinum; the mean results in these cases were that copper cleaned with nitric acid and washed in distilled water gave the cubic inch of hydrogen in 21 minutes. The strip passed through the fingers as in the platinum experiment. Time required 28½ minutes. A strip of copper oxidised by heating in air furnished the hydrogen in 10 minutes. It would appear from these results, that copper behaves in a similar way as to cleanness of surface as platinum, and that the oxidised surface tends rather to facilitate the liberation of the hydrogen—perhaps from mechanical action, like platinised silver. Expt. 5. Platinised silver, as obtained from the makers, arranged in the same way as the foregoing experiments, furnished the 1 cubic inch hydrogen in 2¼ minutes. A strip cleaned with oil of vitriol as usual, time 2¼ minutes. A strip made dirty by the fingers, time 3 minutes. Hence it appears that the mechanical action of the platinum surface is of great importance, as has been well known, and that as received from the makers it is very considerably cleaner than the new platinum, because, probably, of its method of preparation. It was also found that, comparing smooth with mechanically roughened surfaces of platinum, the latter furnished the hydrogen in two-thirds of the time taken by the former. Expt. 6. A cell of Smee's battery was examined by the galvanometer, using in every case a regular strength of acid, the same wires and all conditions the same, when the following results were obtained:—The negative plate not chemically cleaned, deflection = 52°. Negative plate chemically cleaned, 57°. Negative plate made dirty by fingers, 48°. The platinum taken off the surface gave deflection 50°. Here it appears, then, that the cleaning of the surface of the platinised silver materially diminishes the resistance due to the counter-current and polarisation. The last series of experiments were directed to ascertain the influence of chemically clean surfaces upon electrolysis. A voltameter, the electrodes of which were in their ordinary state, was attached to two cells of Bunsen's battery, and the mixed gases collected with all precaution. The time taken for 1 cubic inch was 2 minutes as a mean of many experiments. The electrodes were then cleaned with hot oil of vitriol, the Bunsens freshly charged, and the 1 cubic inch of gases was furnished in 1¼ minutes; thus showing that electrolysis is materially affected by the state of cleanness of the electrodes at the time.

BIOLOGICAL NOTES.

M. Alph. Milne-Edwards has contributed to the Academy of Sciences a very important paper on the Embryology and Zoological Position of the *Lemuridæ*, having obtained from M. Grandidier (in his last Madagascar exploration) specimens of four different genera of distinct groups of these animals in the fœtal state, and submitted them to careful anatomical investigation. His dissections prove that in regard to intra-uterine life there are essential differences between the *Lemuridæ* and the *Simiadæ*. In the latter the placenta is small, discoid, and closely connected to the uterine wall, and the umbilical vesicle is very minute and soon disappears. In the *Lemuridæ* (taking *Propithecus* as the highest type and nearest to the *Simiadiæ*) the chorion is almost entirely covered with thick and serrated villosities, forming a kind of vascular cushion, and constituting a placenta which encaps the amnios, and which he names the *placenta en cloche*, in contrast with the *discoidal placenta* of the human race, and of the *Simiadæ*, the *zonar placenta* of the Carnivora, and the *diffuse placenta* of the Herbivora. The villosities are in large tufts towards the middle and upper parts of the ovum, and gradually diminish towards the cephalic pole, when they disappear. The *caduque utérine* (uterine decidua) is well developed and presents a corresponding arrangement.

Between the chorion and the amnios there is a large membranous sac extending in the direction of the long axis of the ovum, and adhering to the umbilical end by a short thin pedicle. This sac is prolonged at each end into a kind of finger-shaped cornu, is only very slightly attached to the adjacent membranes, and if air is injected into it, under water, we see it expand and its outlines become well marked. It represents the umbilical vesicle much less developed than in most of the *unguiculata*.

The placenta presents the same character in the genera *Lepilemur*, *Hapalemur*, and *Chirogalus*.

From this study of the fœtal membranes of the *Lemuridæ*, it follows that they essentially differ from those of any other mammal. This special type deviates further from that presented by man, the apes, the Cheiroptera, the Insectivora, and the Rodentia, than from that of the Carnivora; for if we suppose for an instant that the caudal pole of the ovum of the dog is invested by the villosities of the placenta, we have an almost exact realisation of the special characters of the Lemurian ovum; and it may be added that the arrangement of the umbilical vesicle is very nearly the same in these two types, while in the apes it is completely different.

These embryological characters are in complete accordance with those furnished by the brain, the cranium, the dental system, and the hands.

The brain of even the highest *Lemuridæ* is not developed posteriorly so as to cover the cerebellum,—a condition which separates them from the apes.

The orbit, which in the apes is completely enclosed outwardly, and separated from the temporal fossa, communicates freely with the latter in all the *Lemuridæ*, and gives their crania a resemblance to those of the Carnivora.

The teeth arming the lower jaw are very different in the two, the distinction between the canines and the incisors being much the more marked in the apes.

The hands, in which the thumb is always well developed and usually opposable to all the other digits, differ from those of the apes. They are admirably adapted for climbing, but are unfitted for the prehension of food, which these animals usually seize with the mouth. The fingers, instead of tapering towards the ends as in the apes, enlarge at their extremities into discoidal pads, imperfectly covered by the nail; and lastly, as is well known, the index finger of the posterior hand terminates in a true claw.

On these and other grounds the author considers that the order *Lemuridæ* must be removed from the *Simiadæ*, and placed in close affinity with the Carnivora.

The embryo of *Macropus major*, the giant kangaroo, has been carefully studied *in situ* by Professor Pagenslecher, and we extract the following remarks from his article in the "Verhand. des Naturh. Vereins zu Heidelberg," as translated in a late number of the "Annals of Natural History:"—

"The left tube contained an embryo, although no yellow body was to be recognised in the ovary. The very vascular decidua separated pretty readily from the walls of the tube, except a few stronger vascular adhesions. The chorion had no connection at all with the decidua, so that it slipped quite easily out of the envelope. The embryo was exactly of the size and maturity of the specimen of which Owen says that it was born thirty-eight days after copulation, and which he has figured. It was enveloped in the amnios. The length from the snout to the extremity of the tail was about 4 centimetres.

"Nothing was to be observed in the way of a preparation of the median sac for the further retention and nourishment of the ovum, nor anything of a preparatory dilatation of the lateral passages.

"In the ventral pouch the left teat was much longer than the right one; but whether from previous sucking or as a preparation I cannot say.

"In comparison with other embryos that of the giant kangaroo is very considerably inferior to an unborn rabbit or a newly born ferret; its size agrees pretty closely with that of an unborn mouse.

"In this comparison the small development of the hinder extremities is remarkable. Whilst on the fore feet the five toes are very distinctly formed even to the claw tips, the hind feet resemble a short-stalked fin, slightly notched into three lobes; the inner lobe is again scarcely perceptibly divided to correspond with the ultimate number of toes. This imperfection of a subsequently most important pair of limbs, in contrast with the perfection of a pair which are afterwards much weaker, is doubtless in accordance with the general law, according to which early completion of form limits growth.

"In the anatomy of the adult animal it may be interesting to mention the existence of a long but fine *ductus Botalli*, showing that even before birth the formation of the partitions of the heart arrives at the same completeness as in placental mammals."

"Professor Cope, of Philadelphia, has recently visited both the Mammoth and the Wyandotte Caves, and has studied the forms of life occurring in each. As the inhabitants of the former have been often described, we shall merely give his list of the latter, with his remarks on their peculiarities and mode of life.

"VERTEBRATA.—*Amblyopsis*, sp. (blind fish.)

"ARTICULATA.—Insects: *Anophthalmus Tellkampfii* (beetle); *Anophthalmus*, No. 2 (beetle); *Staphylinidæ*, sp. 1 (beetle); *Staphylinidæ*, sp. 2 (beetle); *Phalangopsis*, sp. (crickets); Flies: 2 species. Spiders: (beetle); *Aranea*-like, *Opilio*-like. Centipedes: *Pseudotremia*, sp.

"CRUSTACEA.—*Astacus pellucidus* (blind crawfish); aquatic species with egg-pouches external; *Lernæidæ*, species parasitic on blind fish, 14 species.

"The blind fish is very much like that of the Mammoth Cave; and direct comparison will be necessary to determine any difference if it exist. It must have considerable subterranean distribution, as it has undoubtedly been drawn up from four wells in the neighbourhood of the cave. Indeed it was from one of these, which derives its water from the cave, that we procured our specimens; and I am much indebted to my friend N. Bart. Walker, of Boston, for his aid in enabling me to obtain them. We descended a well to the water, some twenty feet below the surface, and found it to communicate by a side opening with a long, low channel, through which flowed a lively stream of very cold water. Wading up the current in a stooping posture, we soon reached a shallow expansion or pool. Here a blind crawfish was detected crawling round the margin, and promptly consigned to the alcohol-bottle. A little further beyond deeper water was reached, and an erect position became possible. We drew the seine in a narrow channel, and after an exploration under the bordering rocks secured two fishes. A second haul secured another. Another was seen, but we failed to catch it, and on emerging from the cave I had a fifth securely in my hand as I thought, but found my fingers too numb to prevent its freeing itself by its active struggles.

"If these *Amblyopses* be not alarmed they come to the surface to feed, and swim in full sight like white aquatic ghosts. They are then easily taken by the hand or net if perfect silence is preserved; for they are unconscious of the presence of an enemy except through the medium of hearing. This sense, however, is evidently very acute, for at any noise they turn suddenly downward and hide beneath stones, &c. on the bottom. They must take much of their food near the surface, as the life of the depths is apparently very sparse. This habit is rendered easy by the structure of the fish; for the mouth is directed upwards, and the head is very flat above, thus allowing the mouth to be at the surface. This structure also probably explains the fact of its being the sole representative of the fishes in subterranean waters. No doubt many other forms were carried into the caverns since the waters first found their way there; but most of them were, like those of our present rivers, deep water or bottom feeders. Such fishes would starve in a cave river, where much of the food is carried to them on the surface of the stream. The *Amblyopsis* belongs, with two other genera of imperfect seers, to the family *Hypsæidæ*, which, with the pike, shore-minnow, and mud-fish families, form the order of *Haplomi*.

"Of the other animals, one beetle (*Anophthalmus*), the cricket (*Phalangopsis*), a fly, the *Opilio*-like spider, the centipede, and the blind crawfish, are probably the same as those found in the Mammoth Cave. Two beetles and two crustaceans are certainly different from those of the latter, and the centipedes are much more numerous. The Gammaroid crustacean which we find in the waters of the Mammoth Cave, and which is no doubt, in part, the food of the blind fish, we did not find; but some such species no doubt exists.

"The mutual relations of this cave-life form an interesting subject. In the first place, two of the beetles, the crickets, the centipede, the Gammaroid crustacean (food of the blind fish), are more or less herbivorous; they furnish food for the spiders, crawfish, *Anophthalmus*, and the fish. The vegetable food supporting them is, in the first place, fungi, which in various small forms grow up in damp places in the cave; they can always be found attached to excrementitious matter dropped from the bats, rats, and other animals which extend their range in the outer air."

The history of the development of the *wing of the butterfly* in the larva and the chrysalis has been carefully studied by Dr. Landois, who, after noticing the labours of Swammerdam and later observers on this subject, proceeds to describe—(1) The development of the wing in the caterpillar; (2) The change which it undergoes in the chrysalis stage; and (3) The processes that go on in the completed wing. The paper, which is too strictly anatomical to admit of a popular analysis, is a very valuable one, and is illustrated by highly magnified figures of the wing-germs of the fore and hind wings after the first moulting of the larva, and likewise after the second and fourth moultings; of a section of the wing in the chrysalis state; of the venation of the perfect wing, &c.—("Zeitsch. f. Wissensch. Zoologie:" Dritter Heft, 1871).

Mr. E. Ray Lankester has just published in the "Quarterly Journal of Microscopical Science," an elaborate paper entitled "Observations and Experiments on the Red Blood-Corpuscle, chiefly with Regard to the Action of Gases and Vapours;" and the following paragraph contains his "general conclusions and summary." The red blood-corpuscle of the vertebrata is a viscid and at the same time elastic disk, oval, or round in outline, its surface being differentiated somewhat from the underlying material, and forming a pellicle or membrane of great tenuity, not distinguishable with the highest powers (whilst the corpuscle is normal and living), and having no pronounced inner limitation. The viscid mass consists of, or rather *yields*, since the state of combination of the components is not known, a variety of albuminoid and other bodies, the most easily separable of which is hæmoglobin; secondly, the matter which segregates to form Roberts's macula; and thirdly, a residuary stroma, apparently homogeneous in the Mammalia (excepting so far as the outer surface or pellicle may be of a different chemical nature), but containing in the other vertebrata a sharply definable nucleus, this nucleus being already differentiated, but not sharply delineated during life, and consisting of (or separable into) at least two components, one (paraglobulin) precipitable by CO_2, and removable by the action of weak NH_3; the other pellucid and not granulated by acids. The chemical differentiation of the outer pellicle is rendered probable by the behaviour of the corpuscles under weak NH_3, which appears to dissolve this pellicle, and so loose the viscid matter from that which restrained it to its oval shape; also from the inability of CO_2 to act on the corpuscle until it has been subjected to the influence of aqueous vapour, which may be supposed to remove or render permeable this pellicle; also from the action of chloroform, oil, and cyanogen, which cause the discharge or diffusion of the hæmoglobin from the corpuscle, perhaps by first removing or rendering permeable—at any rate modifying—this outer pellicle. Steam, chloroform, benzine, bisulphide of carbon, ammonia, and cyanogen, act on the red blood-corpuscle so as to cause the escape of the hæmoglobin. The further action of these reagents causes the elimination of what may be called Roberts's constituent, that which is stained by magenta and set by tannin. A still further action of chloroform, of water, or of ammonia, dissolves first the stroma, lastly the nucleus. The details of these actions are given in the paper. Carbonic oxide and sulphuretted hydrogen produce their respective changes on the hæmoglobin, as demonstrated spectroscopically, without altering the form of the corpuscle, merely effecting the radiation of its body.

In the same number of that journal Dr. Sanderson has discussed the question of the supposed "spontaneous generation of bacteria in certain solutions," which attracted attention in France, and more recently, owing to Dr. Bastian's statements, in this country. Dr. Sanderson shows, First,—That neither bacteria nor fungi ever develope in solutions raised to the boiling-point and placed in carefully cleansed and boiled vessels, which are subsequently closed. Secondly—That if such solutions in such flasks be exposed to atmospheric air, no bacteria ever develope, but yeast-cells and ultimately blue mould do develope (whence it is inferred that the germs of fungi but not of bacteria are carried in the air). Thirdly—That if unboiled water be used, or glass or other surface not duly cleansed be brought into contact with the above-mentioned solutions, bacteria always develope in great quantity (whence it is inferred that water, and surfaces which have been or are more or less damp, are the means of dissemination of bacteria).

Dead or Alive?—A new and very simple method of distinguishing between real and apparent death has been recently discovered by M. Laborde. When a sharp steel needle (not cased only with steel) is driven into the tissues of a living man or animal, in a short time it loses its metallic lustre and becomes dim, or in scientific language—is oxidised; while a similar needle may remain for an hour or more in the tissues of a dead subject without undergoing any apparent change. Hence the oxidation or non-oxidation of the needle affords a decisive proof whether death is real or only apparent.

PSYCHIC FORCE.

THE reception accorded to my previous paper on Psychic Force has been so satisfactory that, had they been in a sufficiently advanced state, I should not hesitate to continue the publication of my investigations. Time which I hoped to spend in research has been occupied in the necessary task of vindicating my honour against adverse criticism. I wish my scientific friends to have an opportunity of seeing my reply to the attacks upon me; but I am reluctant to introduce personalities into the pages of the "Quarterly Journal of Science." I have therefore decided to embody the answers to my objectors in a pamphlet, the publication of which Messrs. Longman have been good enough to undertake. Copies are bound up with the advertisement sheets of this number.

Let me take this opportunity of explaining the exact position which I wish to occupy in respect to the subject of Psychic Force. I have desired to examine the phenomena from a point of view as strictly physical as their nature will permit. I wish to ascertain the laws governing the appearance of very remarkable phenomena which at the present time are occurring to an almost incredible extent. That a new form of Force—whether it be called psychic force or *x* force is of little consequence—is involved in this occurrence, is not with me a matter of opinion, but of absolute knowledge; but the nature of that force, or the cause which immediately excites its activity, forms a subject on which I do not at present feel competent to offer an opinion. I wish, at least for the present, to be considered in the position of an electrician at Valentia, examining with the utmost refinement of instrumental means certain electrical currents and pulsations passing through the Atlantic cable, independently of their causation, and ignoring whether these phenomena are produced by imperfections in the testing instruments themselves—whether by earth currents or by faults in the insulation—or whether they are produced by an intelligent operator at the other end of the line.

W. C.